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ERRATA.

Page 76, line 3 from top, after lines add, of faults; line 5 from top, for streets, read straits; line 2 from foot, for and, read one; line 3 from foot, for Velaine, read Vélain; line 8 from foot, for Mont Alban, read Montalban; line 13 from foot, for feldspar, read feldspars. Page 77, line 11 from foot, for von Hautken, read von Hantken.

Page 317, lines 25, 26 from top, transpose H_2O (comp.) and H_2O (hygr.)

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ART. I.—*Contributions to Meteorology: being results derived from an examination of the observations of the United States Signal Service, and from other sources;* by ELIAS LOOMIS, Professor of Natural Philosophy in Yale College. Tenth paper. With Plates I and II.

[Read before the National Academy of Sciences, New York, Nov. 6, 1878.]

Storms of the Atlantic Ocean.

IN a former paper, I have noticed some storms which could be traced across the Atlantic Ocean by means of the Paris storm charts from June, 1864, to December, 1865, and Hoffmeyer's charts from December, 1873, to August, 1874. Having received a copy of Hoffmeyer's charts complete to November, 1875, I have undertaken a more careful examination of Atlantic storms. I first provided myself with a large number of blank maps of the Atlantic Ocean, upon precisely the same scale as Hoffmeyer's charts, so that observations could be readily transferred from Hoffmeyer's charts to my own. I then made a careful examination of all the charts in succession. For the first three months (December, 1873, to February, 1874), the isobars are not drawn beyond the meridian of 30° west of Paris, so that these charts were not available for this investigation. For the month of March, 1874, I selected the first chart, which showed an isobar as low as 750 millimeters (29·5 inches), near the coast of the United States, and marked upon one of my maps the position of the center of the lowest isobar. If the same low area could be identified on the chart of the following day, I marked upon my map the position of the center of the lowest isobar for that date, and I did the same for each following day as long as the low area could be identified. The

Storms of the Atlantic Ocean.

		First appearance.			Long. 60°.		Long. 30°.		Long. 0°.		From 60° to 0°.		On English Coast.	
No.	Date.	Lat.	Long.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Days.	Aver. velocity	Highest wind.	Direc'n of wind.
	1874.													
1	Mar. 4	46°·5	75°·5	745										
2	8	47·0	77·1	750	48°·1	745	60°·7	740	68°·7	735	2·8	36·4	4	S.W.
3	20	47·0	61·3	740	49·2	740	65·0	730	72·5	745	4·0	24·8	4	W.N.W.
4	23	53·5	55·0	740	51·4	740	63·2	735	61·8	750	14·6	6·5	3	S.W.
5	April 3	48·6	70·6	750	52·3	750	62·6	745	48·5	740	9·2	12·0	5	W.N.W.
6	12	46·4	63·5	750										
7	15	51·8	74·0	750	50·0	750	60·2	745	67·7	745	6·1	15·8	4	S.
8	21	47·0	75·0	750										
9	26	41·5	72·2	745	44·5	740								
10	30	46·5	71·3	740	44·0	750								
11	May 26	47·0	76·7	750	55·0	750	59·4	745	66·4	755	6·7	12·8	3	W.
12	June 1	43·0	69·3	745										
13	8	48·0	72·0	750	44·5	750								
14	13	50·5	75·0	750	47·8	755								
15	18	44·2	71·8	750										
16	23	52·5	70·0	750	49·1	750								
17	29	45·0	80·0	750										
18	July 8	47·8	71·8	750										
19	16	45·6	71·8	750										
20	Aug. 1	47·5	75·5	745										
21	Sep. 11	49·5	56·4	750										
22	30	45·6	71·8	740										
23	Oct. 11	51·5	71·4	745	59·6	750	61·9	740	68·5	740	7·8	9·6	5	W.
24	18	51·9	68·0	745	54·5	750	64·6	730	69·6	730	5·7	13·8	4	S.W.
25	28	37·0	62·0	750	38·2	750	38·2	755						
26	30	51·3	71·0	750	54·4	755	64·0	740	68·0	740	3·3	22·6	3	S.W.
27	Nov 10	46·6	56·0	745	50·8	745	69 0	745	62·0	740	5·1	16·1	4	N.W.
28	21	44·2	67·8	745	43·3	750								
29	24	48·0	70·0	735										
30	29	46·0	72·7	750										
31	Dec. 9	52·7	56·0	750	49·8	750								
32	15	50·0	59·0	750	49·3	750	62·6	745	64·6	755	9·7	10·2	5	S.W.
33	21	40·0	65·5	750	39·2	755								
34	25	47·4	57·7	740	47·7	740	59·0	735	59·3	740	9·3	11·1	4	S.W.
	1875.													
35	Jan. 3	46·8	60 8	735	47·4	735	59·5	735	61·4	740	13·3	7·7	3	S.W.
36	8	43·5	65·0	740										
37	10	45·4	58·0	750	45·8	750	*	*	*	*	6·0	17·6	3	S.W.
38	14	43·4	66·0	750	47·6	745	58·3	740	61·5	735	5·0	21·1	4	S.W.
39	23	42 8	62·0	750	43·2	750	59·5	740	68·6	740	9·0	12·6	3	S.
40	25	44·5	68·7	750	49·7	745	†	†	†	†	6·5	14·9	3	S.
41	30	43·0	63·6	750	43·0	750	56·8	745	68·5	750	16·3	6·9	3	S.W.
42	Feb. 1	41·5	63·0	745	44·7	745	†	†	†	†	14·1	7·7	3	S.W.
43	8	40·5	64·5	740	43·6	745	†	†	†	†	7·0	16·0	3	S.W.
44	12	47·6	66·3	740	59·0	740								
45	20	45·0	84·3	750										
46	26	46·5	64·0	730	51·0	735	47·3	725	73·0	740	10·5	9·1	5	W.
47	Mar. 7	39·8	57·2	750	41·5	750								
48	8	40·5	67·0	745	42·3	745	†	†	†	†				
49	17	46·0	68·0	745	53·2	740	63·2	720	67·6	745	9·3	9·5	4	W.
50	25	42·4	68·4	745	60·4	745	64·8	755	63·7	740	7·7	10·1	4	W.

Storms of the Atlantic Ocean.

		First appearance.			Long. 60°.		Long. 30°.		Long. 0°.		From 60° to 0°.		On English Coast.	
No.	Date.	Lat.	Long.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Lat.	Lowest isobar.	Days.	Aver. velocity	Highest wind.	Direct'n of wind.
	1875.													
51	April 6	38°·0	53°·0	750	40°·5	750	45°·2	740	48°·5	755	16·4	7·4	3	E.
52	14	41·5	72·3	750	40·6	750	†	†	†	†	7·4	16·3	3	E.
53	16	45·0	77·3	750	45·3	745	50·2	740	72·8	745	14·1	7·7	3	S.
54	25	39·7	60·0	750	39·7	750	†	†	†	†	9·8	12·6	3	S.
55	30	46·5	77·2	745	47·3	750	47·0	750						
56	May 2	50·0	78·6	740	53·0	750	62·4	745	†	†	†	†		
57	5	42·5	57·5	750	†	†	†	†						
58	7	41·4	67·5	750	41·0	750	54·0	745	67·7	750	7·0	17·0	3	W.
59	12	45·0	83·5	750										
60	Jun. 17	39·9	58·4	750	40·0	750								
61	19	43·2	68·8	745	53·8	745	61·4	745						
62	28	48·5	73·5	750	53·8	750	62·3	750	*					
63	July 17	43·3	66 6	750	44·3	750								
64	25	44·8	59·7	750	44·7	750								
65	30	40·4	67·7	750										
66	Sept. 4	47·4	77·5	750	62·0	750								
67	17	42·5	73·0	750	46·3	745	44·6	735	58·7	730	8·8	12·0	5	W.
68	26	48·3	60·0	750	48·3	750	65·0	740						
69	Oct. 2	50·0	63·0	750	51·8	750	59·6	740	66·7	735	3·2	28·7	3	W.
70	16	47·6	66·2	750	56·8	745	53·4	735	47·8	755	9·9	10·5	4	E. to W.
71	21	44·2	55·7	745	42·7	750	†	†	†	†	7·0	16·0	4	E. to W.
72	25	40·0	64·4	750	40·0	745	49·6	745	64·4	745	10·2	11·7	3	W.
73	28	48·6	63·5	750	48·3	750	†	†	†	†	7·2	13·9	3	W.
74	31	43·7	72·0	740	45·3	740	52·4	750	52·0	725	8·9	12·4	5	N.W.
75	Nov 11	43·5	69·6	735	45·9	740	53·8	745	56·8	755	6·0	17·9	4	W.
76	17	46·6	64·7	725	47·5	740								
77	29	47·3	70·0	750	48·8	740								
	Means			746	49·6	746	58·0	740	63·3	743	8·5	14·0		

* This low area appeared to coalesce with No. 35.

† This low area appeared to coalesce with the low next preceding.

points thus determined were connected by straight lines, and the probable track of the low area was thus obtained. The same method was pursued with each of the charts to November 30, 1875. I thus obtained seventy-seven cases of low areas near the coast of the United States, and was able to follow thirty-six of them with considerable confidence entirely across the Atlantic Ocean; but eight of these storms became merged in other storms before reaching the European coast, leaving only twenty-eight different low areas which reached the coast of Europe. The preceding table exhibits the most important particulars relating to these seventy-seven cases. Column 1st contains the number for reference; column 2d shows the date of the chart upon which a low area was first found near the coast of the United States; column 3d shows the latitude, and column 4th the longitude of the center of the lowest isobar for the date mentioned in column 2d, and column 5th shows the amount of the lowest isobar. As the isobars are drawn at intervals of five millimeters, it is probable that at the center of the low area the pressure was frequently as low as 745 m. (29·3 inches), and sometimes lower. Column 6th shows the latitude in which the central path of the low area crossed the meridian of 60° W. from Paris, and column 7th shows the lowest isobar for that position; column 8th shows the latitude in which the central path crossed the meridian of 30° W. of Paris, and column 9th shows the lowest isobar for that position; column 10th shows the latitude in which the central path crossed the meridian of Paris, and column 11th shows the lowest isobar in that position; column 12th shows the number of days required for the low center to travel from the meridian of 60° to that of Paris; and column 13th shows the average velocity of the center in its course between these two meridians. This average is obtained by supposing the center to have followed the arc of a great circle, and takes no account of the actual irregularities of its course. Column 14th shows the highest wind reported on the English coast at the time the low center was nearest. These winds are estimated upon a scale from 1 to 6, where 1 denotes a light breeze; 2 a fresh breeze; 3 very fresh; 4 a hard wind; 5 a gale, and 6 denotes a hurricane. The velocities given in column 14th are the highest velocities reported anywhere near the coast of England, but do not include Scotland. If Scotland had been included, the velocities in some cases would have been greater. Column 15th shows the direction of the wind corresponding to the velocity in column 14th. Sometimes at several stations the same velocity was reported, but with different directions. The direction given in column 15th is the one which occurs most frequently for the given date and velocity.

We see from this table that in one year there are on an average only eighteen different storms which can be traced by means of Hoffmeyer's charts from the coast of the United States across the Atlantic. If for each day we had two good charts, instead of only one, it is probable that a few more storms might be identified in their progress across the ocean, but it is doubtful whether the number would be greatly increased. Nearly all of these storms pursued a course north of east, and passed considerably to the north of Scotland. In only four of the cases did the low center cross the meridian of Paris in a latitude as low as the northern boundary of England. The average track of the thirty-six low centers which are traced across the ocean, is shown by the means at the bottom of the table, where it is seen that the meridians of 60°, 30° and 0°, were crossed in the latitudes 49°·6, 58°·0 and 63°·3. Since the storm centers generally passed 800 miles north of London, most of them did not exhibit much violence on the English coast. In half of the cases, the highest velocity reported was 3, denoting a very fresh breeze, and in only six of the cases was the velocity at any station on the English coast as high as 5, denoting a gale.

We may hence conclude that when a center of low pressure (below 29·5 inches) leaves the coast of the United States, the probability that it will pass over any part of England is only one in nine; the probability that it will give rise to a gale anywhere near the English coast is only one in six; and the probability that it will give rise to a very fresh breeze is one in two.

One of the most noticeable circumstances connected with Atlantic storms is their slow rate of progress. This is due partly to the erratic course of the center of the low area, and partly to the frequent blending of two low areas into one, whence it generally results that the most eastern center appears to be pushed backward toward the west. In my eighth paper I have described a remarkable example of this kind of movement. In like manner the storms numbered 35, 39, 41, 51, 53, 70 and 72 of the preceding table appeared to be pushed westward by blending with storms of a subsequent date. Aside from this cause of detention, there seems in the Atlantic Ocean to be a special cause which frequently holds storms nearly stationary in position from day to day, and this cause is probably the abundance of warm vapor rising from the Gulf Stream, in close proximity to the cold dry air from the neighboring coast of North America. Hence we see that when American storms are predicted to appear upon the European coast, and it is assumed that they will cross the ocean at the same rate as they have crossed the United States, such predictions will seldom be verified.

It will also be noticed that the storms which cross the Atlantic, generally increase in intensity after leaving the American coast; the average depression of the barometer shown in the preceding table being 6 millimeters (0·24 inch) greater in long. 30° than in long. 60°.

Origin of the storms here traced.—Two of the storms enumerated in the preceding table and which have been traced across the Atlantic (Nos. 51 and 70), appear to have originated over the Atlantic Ocean; five of them (Nos. 46, 52, 54, 73 and 75), appear to have originated in Texas or its vicinity; four of them (Nos. 67, 69, 71 and 74), appeared to originate in the middle latitudes, but considerably east of the Rocky Mountains; about half of the whole number appear to have originated in the neighborhood of the Rocky Mountains; that is, it is difficult to trace them satisfactorily further west; but four of the number can be distinctly traced to the Pacific coast, viz: two of them (Nos. 26 and 41) to California, and two of them (Nos. 39 and 40) to Oregon. The course of No. 39 is represented on Plate I. At 7.35 A. M., January 19th, the barometer at Portland, Oregon, stood at 29·34, and at 4.35 P. M. at 29·22, a depression which has seldom been observed at that place. This low area traveled eastward across the United States with diminishing intensity. On the morning of the 20th, the greatest depression was at Bismark, 29·48; on the morning of the 21st, at Keokuk, 29·75; on the 22d, at Alpena, 29·74; on the 23d, at Sydney, 29·54, and during the next two days the depression still further increased. Another low area had now arrived at Nova Scotia, and on the 26th had approached so near the former that the two seemed inclined to coalesce. On the two following days this tendency became more decided, and on the 29th both were united in one great depression, the pressure near the center being 28·94. This low area advanced toward the northeast without any perceptible diminution of intensity; but when it had nearly reached the North Cape, its course was turned to the southeast. The center of this low area has thus been traced through about 150° of longitude, and considering that the depression was unusually great when first observed in Oregon, it seems safe to conclude that this low area preserved its identity through more than 180° of longitude. It will be seen, however, that this storm of January 19th to February 3d, 1875, was an unusual case. The changes of the barometric depressions are so frequent that a low area can seldom be identified in its progress from the Pacific Ocean to Eastern Europe.

West India Cyclones.—During the period embraced by Hoffmeyer's maps, there occurred several cyclones which originated in or near the Gulf of Mexico. The following cases are noted on the maps of the United States Signal Service:

1. 1874, Sept. 5- 7.
2. " Sept. 9-11.
3. " Sept. 27-30.
4. 1875, Sept. 14-19.
5. " Oct. 13-16.
6. " Nov. 8-11.

No. 1 apparently moved northward and was merged in a larger depression previously existing near South Greenland. No. 2 cannot be certainly identified on the map of September 12th. No. 3 apparently moved northward over Labrador. No. 4 (the great Indianola hurricane) appeared to merge in a greater depression previously existing near Newfoundland, without producing any sensible modification in it. No. 5 can be traced across the Atlantic, but during its progress it blended with one or two other depressions. No. 6 can be traced across the Atlantic, and throughout the entire passage preserved its identity pretty distinctly. Thus we see that of the six cyclones here mentioned, only two can be traced across the Atlantic, and only one of them escaped blending with another depression. These cases (although few in number) suggest the conclusion that the West India cyclones, however violent they may be within the tropics, when they reach the middle latitudes, expand in area and lose much of their violence, and after a few days are usually merged in some of the larger depressions which generally prevail in some part of the North Atlantic Ocean.

Fluctuations of the barometer on Mt. Washington and Pike's Peak.

The Annual Report of the United States Chief Signal Officer for 1873 contains a series of hourly observations of the barometer on the summit of Mt. Washington (elevation 6,285 feet), and also at the base of the mountain (elevation 2,898 feet) during May and June, 1873. I have projected all these observations in curve lines and find a general correspondence between the fluctuations of the barometer at the two stations, with some decided differences, among which the most noticeable is that the maxima and minima of pressure generally occur earlier at the base of the mountain than they do at the summit. The following table shows the principal maxima and minima for the months of May and June, the barometric readings being corrected for temperature and instrumental error only.

Barometer at base and summit of Mt. Washington.

	Date.	Base.		Summit.		Diff.
Min.	May 3	12 M.	26·820	2 P.M.	23·390	+ 2$^{h.}$
Max.	8	7 A.M.	27·547	11 A.M.	24·114	+4
Min.	13	2 P.M.	26·654	6 P.M.	23·147	+4
Max.	21	8 A.M.	27·480	9 A.M.	24·055	+1
Min.	24	1 P.M.	26·822	5 P.M.	23·422	+4
Max.	26	8 A.M.	27·346	9 A.M.	24·029	+1
Min.	28	4 P.M.	26·988	9 P.M.	23·631	+5
Max.	29	10 A.M.	27·187	5 P.M.	23·839	+7
Min.	30	12 P.M.	37·114	5 A.M.	23·607	+5
Max.	31	9 A.M.	27·500	4 P.M.	24·021	+7
Min.	June 5	2 A.M.	26·756	5 A.M.	23·406	+3
Max.	{ 8	6 P.M.	27·388	6 P.M.	24·040	0 }
	{ 9	5 A.M.	27·393	11 A.M.	24·012	+6 }
Min.	11	6 A.M.	27·007	9 A.M.	23·670	+3
Max.	13	4 A.M.	27·430	10 A.M.	24·043	+6
Min.	17	2 A.M.	26·952	4 A.M.	23·540	+2
Max.	18	8 A.M.	27·138	12 M.	23·748	+4
Min.	20	2 A.M.	26·788	4 A.M.	23·468	+2
Max.	25	10 A.M.	27·582	12 M.	24·270	+2
Min.	28	4 A.M.	26·983	5 P.M.	23·708	+13

Several of these maxima and minima are represented on Plate II. The upper curve represents the barometric fluctuations on the summit of the mountain from May 12, 2 P. M., to May 16, 2 P. M., the interval between the horizontal lines representing a difference of one-fiftieth inch pressure, and the interval between the vertical lines representing two hours of time. The second curve represents the barometric fluctuations at the base of the mountain for the same dates. The third and fourth curves represent the fluctuations from May 22, 8 P. M., to May 26, 8 P. M.; and the fifth and sixth curves represent the fluctuations from May 28, 10 A. M., to June 1, 10 A. M. The minimum of May 13th is pretty sharply defined, and occurred on the summit four hours later than at the base. On the morning of May 15th occurred another minimum, which at the summit was sharply defined, but at the base was inconsiderable. The minimum of May 24th was pretty sharply defined at both stations, and the same is true of the maximum May 26th. From May 28th to June 1st occurred two minima and two maxima which are not very sharply defined, but the critical points at the summit evidently lag behind the corresponding points at the base. The maximum of June 8th continued for twenty-four hours with but little change, and the highest reading occurred at the summit of the mountain earlier than at the base, which may be regarded as an exception to the general rule. If, however, we compare the corresponding undulations of the two curves, I think it will appear that the first maximum occurred at both stations at about the same instant, and the second maximum occurred six hours earliest at the base. The decided fall of the barometer began six hours earlier at the base than at the summit. The minimum of June 28th continued for eighteen hours without much change, but the absolute minimum occurred thirteen hours earlier at the base than at the summit.

These observations appear to me to prove that the maxima and minima of the barometer do not generally occur simultaneously at the top and bottom of Mt. Washington, but on an average occur more than three hours later at the summit than at the base, showing an average retardation of one hour for each 900 feet of elevation.

In order to test this result by independent observations, I compared the observations made on the summit of Mt. Washington with those made at Burlington, Vt., and Portland, Me., from September, 1872, to January, 1875. Burlington and Portland are distant from each other about 150 miles, and Mt. Washington is about midway between them, and we might expect that the barometric minima at Mt. Washington would occur at dates intermediate between those at Burlington and Portland. I therefore selected all those cases in which the barometer at Portland fell as low as 29·6 inches, and determined the times of barometric minima at these three stations. The result is shown in the following table, where the numeral 1 following a date denotes the 7.35 A. M. observation; 2 denotes the 4.35 P. M. observation; and 3 denotes the 11 P. M. observation. When the pressure at two successive observations was sensibly the same, I have taken the intermediate date as being the true time of minimum. The fifth column shows the difference between the date of minimum on Mt. Washington and the half sum of the dates at Burlington and Portland expressed in units of eight hours.

Barometric minima at Burlington, Vt., Portland, Me., and Mt. Washington, N. H.

	Burl'n.	Portl'd.	Mt. W.	Diff.		Burl'n.	Portl'd.	Mt. W.	Diff.
1872.	d.	d.	d.		1873.	d.	d.	d.	
Oct.	14.1½	14.1½	14.2	+0·5	Dec.	26.3	26.3	26.3	0·0
	27.1	27.1	27.1	0·0		28.1	28.1	28.2	+1·0
Nov.	7.1	7.2	7.3	+1·5	1874.				
	12.2	12.3	12.3	+0·5	Jan.	8.2	8.2	8.2½	+0·5
	14.3	14.3½	15.1	+0·7		10.1	10.2	10.2	+0·5
	30.1	30.1	30.1	0·0		15.2	15.2½	16.1	+1·7
Dec.	2.3	3.1	3.1	+0·5		23.1	23.2	23.2	+0·5
	9.1	9.3	10.1	+2·0		28.1	28.2	28.3	+1·5
	27.2	27.2	28.1	+2·0	Feb.	10.2½	10.3	11.1½	+1·7
1873.						13.3	14.1	14.1	+0·5
Jan.	3.3	3.3	4.1	+1·0		16.2	16.3	17.1	+1·5
	5.3	5.3	6.1	+1·0	March	4.1	4.2	4.2	+0·5
	21.3	22.1	22.1	+0·5		9.1	10.1½	10.1	+1·2
	27.2	27.3	27.3	+0·5		19.2	19.3	20.1½	+2·0
Feb.	4.2	4.2	4.2½	+0·2		22.3	23.1	23.1	+0·5
	8.1	8.1	8.2	+1·0		26.2	26.3	26.3	+0·5
	21.2½	21.3	22.2	+1·2	April	3.1	3.2	3.2	+0·5
March	3.2	3.2	3.3	+1·0		15.2	15.2	16.1	+2·0
	8.2½	9.1	9.1	+0·7		21.1	21.1	21.1½	+0·5
	16.1	16.1½	16.3	+1·7		26.1	26.1	26.1	0·0
	21.1½	21.1½	21.2½	+1·0		30.2	30.1	30.2	+0·5
	23.2	23.3	24.1	+1·5	May	5.2½	5.2	5.3½	+1·2
	26.2	26.3	27.1	+1·5		25.2½	25.3	25.3½	+0·7
	29.3	30.1	30.1	+0·5		31.2½	31.2½	32.1	+1·5
	31.1	31.2	31.2	+0·5	June	7.3½	8.1	8.2	+1·2
April	14.2	14.2	14.1	−1·0		17.2½	17.3½	17.3½	+0·5
	19.1½	19.2	19.3	+1·2		23.2	23.3	24.1	+1·5
	25.3½	26.1½	26.1	0·0		28.2	28.2	28.3	+1·0
May	13.1	13.2	13.2	+0·5	Aug.	1.2	1.2	1.2	0·0
	24.1½	24.2	24.2	+0·2	Sept.	30.1	30.1	30.2	+1·0
June	4.2½	4.2½	4.3½	+1·0	Oct.	2.2	2.2	2.3	+1·0
	19.3	20.2	20.2	+1·0		10.2½	10.3	11.1	+1·2
Sept.	1.2	1.2	2.1	+2·0		17.3½	18.2	18.3½	+2·2
Oct.	7.1	7.1	7.1	0·0	Nov.	10.3½	11.1½	11.3	+2·0
	12.1	12.2	12.3	+1·5		20.3	20.3	21.1	+1·0
	27.1	27.2	27.2	+0·5		23.3	23.3	23.3½	+0·5
Nov.	8.2	8.2	8.3	+1·0		29.1½	29.1½	29.2	+0·5
	12.3	12.3	13.1½	+1·5	Dec.	17.2	17.3	18.1	+1·5
	18.2	18.2	18.2	0·0		24.1½	24.2	24.2	+0·2
Dec.	4.1	4.2	4.2½	+1·0	1875.				
	13.2	13.3	13.3	+0·5	Jan.	2.2	2.2	2.3	+1·0

It will be seen that in one instance the minimum at Mt. Washington occurred earlier than it did at Burlington or Portland; in eight cases the minima occurred simultaneously; in seventy cases the minimum on Mt. Washington occurred later than the half sum of the dates at Burlington and Portland, the average difference being 0·88, or seven hours. The height of Mt. Washington above Burlington and Portland is 6,148 feet, showing an average retardation of one hour for an elevation of 870 feet.

I next compared the observations made at the summit of Mt. Mitchell in North Carolina (elevation 6,691 feet) with those made at the base of the mountain (elevation 2,560 feet) from August 6th to September 5th, 1873, published in the Report of the United States Chief Signal Officer for 1873, but the fluctuations of the barometer were too small to yield satisfactory results. The following are the most noticeable coincidences of minimum pressure:

	Base.	Summit.	Difference.
1873. Aug. 13	3 P.M.	4 P.M.	+1 hour.
15	2 A.M.	5 A.M.	+3 hours.
25	5 P.M.	7 P.M.	+2
27	2 A.M.	4 A.M.	+2
Sept. 4	3 P.M.	7 P.M.	+4
5	3 P.M.	6 P.M.	+3

These results indicate an average retardation of one hour for an elevation of 1,600 feet, but the fluctuations are so small that no great importance can be attached to them except as they are taken in connection with other observations.

I next compared the observations made on Pike's Peak (elevation 13,960 feet) with those made at Colorado Springs, the base of the mountain (elevation 5,850 feet), a copy of which observations I have received in manuscript through the kindness of General Myer. When the observations at these two stations are projected in curves, the differences between the two curves are seen to be considerable, but there is a large number of cases in which the resemblance is very decided. The following table contains those cases in which the dates of maximum and minimum pressure are most sharply defined. There are many other cases in which the general resemblance of the curves is very decided, but the change of curvature is too gradual to admit of a satisfactory comparison of the instants of maximum or minimum pressure. The table shows the date (hour and minute) of several maxima and minima both at Colorado Springs and Pike's Peak, and the last column shows the difference between the dates of the critical points at the two stations.

Barometer at Colorado Springs and Pike's Peak.

No.		Date.	Colorado Springs.		Pike's Peak.		Diff.
			h. m.	barom.	h. m.	barom.	h. m.
1	Max.	1873. Nov. 16	10.25 A.M.	30·15	4.25 P.M.	30·12	+ 6.10
2	Min.	22	7.35 A.M.	29·69	7.35 A.M.	29·64	0.00
3	Min.	Dec. 2	3.52 P.M.	29·48	3. 7.35 A.M.	29·18	+15.43
4	Min.	7	4.35 P.M.	29·58	7.47 P.M.	29·47	+ 3.12
5	Min.	11	4.35 P.M.	29·60	4.35 P.M.	29·48	0.00
6	Max.	13	8.13 A.M.	30·27	7.47 P.M.	30·18	+11.34
7	Max.	24	8.13 A.M.	30·27	11.00 P.M.	30·12	+14.47
8	Min.	25	11.00 P.M.	29·80	26. 7.35 A.M.	29·75	+ 8.35
9	Min.	1874. Jan. 3	7.35 A.M.	29·28	4.35 P.M.	29·32	+ 9.00
10	Max.	6	12.00 M.	30·17	7.47 P.M.	30·03	+ 7.47
11	Min.	26	4.35 P.M.	29·71	27. 7.35 A.M.	29·65	+15.00
12	Max.	28	8.13 A.M.	30·19	11.00 P.M.	30·07	+14.47
13	Max.	Feb. 8	12.00 M.	30·12	9. 7.35 A.M.	29·93	+19.35
14	Min.	12	10.25 A.M.	29·31	4.35 P.M.	29·20	+ 6.10
15	Max.	19	11.00 P.M.	29·81	11.00 P.M.	29·64	0.00
16	Min.	March 5	11.00 P.M.	29·43	4.35 P.M.	29·36	— 6.25
17	Min.	30	4.13 P.M.	29·65	4.35 P.M.	29·58	+ 0.22
18	Max.	April 2	8.52 A.M.	30·19	4.35 P.M.	29·95	+ 7.43
19	Min.	4	4.13 P.M.	29·63	4.35 P.M.	29·60	+ 0.22
20	Min.	May 1	4.35 P.M.	29·50	2. 7.35 A.M.	29·50	+15.00
21	Min.	9	3.52 P.M.	29·39	4.35 P.M.	29·46	+ 0.43
22	Max.	Oct. 21	11.00 P.M.	30·28	22. 12.00 M.	30·27	+13.00
23	Min.	24	7.35 A.M.	29·64	7.35 A.M.	29·63	0.00
24	Max.	26	12.00 M.	30·21	4.35 P.M.	30·11	+ 4.35
25	Min.	28	7.35 A.M.	29·59	3.17 A.M.	29·63	— 4.18
26	Max.	30	11.00 P.M.	30·31	11.00 P.M.	29·98	0.00
27	Max.	Nov. 12	12.00 M.	30·16	4.35 P.M.	30·06	+ 4.35
28	Min.	22	7.35 A.M.	29·32	7.35 A.M.	29·37	0.00
29	Max.	25	1.25 A.M.	29·98	7.35 A.M.	29·95	+ 6.10
30	Min.	Dec. 15	4.35 P.M.	29·58	7.47 P.M.	29·56	+ 3.12
31	Max.	23	11.00 P.M.	30·08	11.00 P.M.	29·79	0.00
32	Max.	1875. Jan. 21	4.35 P.M.	30·03	11.00 P.M.	29·76	+ 6.25
33	Min.	22	11.00 P.M.	29·75	23. 7.35 A.M.	29·54	+ 8.35

In a majority of the cases, the critical points occur several hours later on Pike's Peak than at Colorado Springs. In ten of the cases the difference was less than one hour, and in two cases the minimum appeared to occur earlier at the summit than at the base of the mountain. These anomalies are, however, more apparent than real. In No. 16 the barometer at Pike's Peak was lowest at 4.35 P. M., but at 7.35 A. M. of the next day it had risen only 0·02 inch. In No. 25, at the time of the minimum at Colorado Springs, the barometer at Pike's Peak had not yet begun to rise, so that we may claim that in both of these cases the minima occurred sensibly at the same instant at both stations. The average retardation indicated by all the cases in the table is $5^h\ 50^m$, or one hour for an elevation of 1,380 feet.

The number of cases here examined appears to be sufficient to warrant the following conclusions: that over the United States, both the maxima and minima of atmospheric pressure generally occur first near the surface of the earth, and they occur later as we rise above the surface, the retardation amounting to one hour for an elevation of from 900 to 1,300 feet.

Since the changes in the pressure of the air generally begin at the surface of the earth, it might be presumed that the changes in the direction of the wind must follow the same law. In order to decide this question I selected all those cases in which the wind on the summit of Mt. Washington blew from either the points S., S.E., E. or N.E., according to the hourly observations during the months of May and June, 1873. The number of these cases was 196, and they belong to ten different periods whose duration is shown in column 3d of the following table. Column 2d shows the direction of the wind during this period, and column 4th shows the number of hours at which this wind was observed.

Comparison of winds at the base and summit of Mt. Washington.

No.	On the summit of Mt. Washington.			Surface winds from the East.	
	Wind.	Duration.	H'rs.	Began.	Ended.
1	S. to E.	May 2, 2 P.M. to May 3, 6 P.M.	29	7 h'rs earliest.	4 h'rs latest.
1	S. to E.	May 9, 1 A.M. to May 10, 4 P.M.	40	11 " "	2 " earliest.
3	S.	May 11, 11 A.M. to May 12, 5 A.M.	19	12 " "	8 " earliest.
4	S.	May 21, 11 A.M. to May 21, 4 P.M.	6	12 " "	5 " earliest.
5	S.	May 26, 10 A.M. to M. 26, 11 A.M.	2	Uncertain.	Uncertain.
6	S.E. to N.E.	June 7, 7 P.M. to June 10, 11 A.M.	46	Variable.	Variable.
7	N.E.	June 13, 2 A.M. to June 13, 8 A.M.	4	6 hr's earliest.	Uncertain.
8	S. to S.E.	June 14, 1 P.M. to June 15, 1 A.M.	10	6 " "	2 h'rs latest.
9	S.E. to N.E.	June 22, 9 P.M. to June 25, 3 P.M.	36	Simultaneous.	Variable.
10	S.	June 29, 6 P.M. to June 29, 9 P.M.	4	Simultaneous.	Variable.

In the case of Nos. 6, 7, 8 and 9 the interval named in column 3d exceeds the number of hours mentioned in column 4th, and includes several hours of calms, besides a few hours in which there was a feeble wind from the N. or W. points. Column 5th shows when the surface winds began to blow from S., S.E., E. or N.E.; and column 6th shows when these winds changed to north or west. The time here given for the change of the surface winds is designed to indicate the time of general change at the neighboring stations, and does not depend exclusively upon observations at the base of the mountain. It will be seen that the surface winds generally began to blow from the east several hours before the change took place on the summit of Mt. Washington. The change of wind back from east to west sometimes occurred first at the base and sometimes it occurred first on the summit. The term *variable* in column 6th denotes that the surface winds were feeble, and fluctuated for several hours between east and west.

It will be noticed that during the entire period of the barometric oscillations represented on Plate II, the wind on Mt. Washington never blew from the S., S.E., E. or N.E., and the same is true of the four minima in the months of May and June, 1873, mentioned on page 9. Thus we see that areas of low barometer frequently occur accompanied by surface winds from the south and east, while the winds on Mt. Washington blow uninterruptedly from the western quarter; and in those cases in which the wind on Mt. Washington blows from an eastern quarter, the change from west to east generally occurs first at the base of the mountain.

It is also noticeable that the diurnal movements of the barometer exhibit a peculiarity similar to that found for the accidental fluctuations. This is shown by the following table,

Mean height of the barometer at all hours of the day.

	Mount Washington, New Hampshire.								Mt. Mitchell, N. C.	
	Month of June.				Month of May.		May and June.		August.	
	Stat'n 1	Stat'n 2	Stat'n 3	Stat'n 4	Stat'n 1	Stat'n 4	Sum't.	Base.	Sum't.	Base.
1 A.M.	23·818	24·512	25·979	27·179	23·702	27·152	23·760	27·165	23·720	27·355
2	·815	·513	·975	·173	·699	·149	·757	·161	·714	·351
3	·806	·508	·971	·170	·696	·147	·751	·158	·711	·347
4	·802	·511	·976	·175	·690	·146	·746	·160	·706	·349
5	·805	·513	·982	·181	·701	·150	·753	·165	·713	·357
6	·811	·513	·987	·189	·701	·158	·756	·173	·720	·368
7	·817	·520	·993	·196	·707	·164	·762	·180	·731	·373
8	·821	·527	·996	·196	·714	·166	·767	·181	·739	·378
9	·828	·532	·998	·196	·718	·166	·773	·181	·748	·379
10	·838	·536	·999	·196	·725	·165	·781	·180	·753	·374
11	·839	·533	·997	·190	·731	·162	·784	·176	·753	·363
noon	·841	·532	·992	·182	·733	·156	·787	·169	·746	·354
1 P.M.	·839	·532	·985	·177	·731	·149	·785	·163	·737	·345
2	·834	·527	·985	·171	·732	·143	·783	·157	·730	·333
3	·830	·528	·976	·161	·725	·142	·777	·152	·726	·330
4	·825	·521	·973	·158	·725	·142	·775	·150	·719	·321
5	·817	·520	·973	·152	·724	·147	·771	·150	·717	·323
6	·822	·517	·973	·156	·721	·154	·771	·155	·717	·329
7	·818	·523	·976	·165	·727	·162	·772	·163	·723	·345
8	·818	·522	·980	·166	·727	·166	·773	·166	·730	·360
9	·826	·531	·984	·173	·733	·170	·779	·171	·737	·361
10	·823	·522	·983	·172	·727	·170	·775	·171	·739	·861
11	·821	·522	·981	·174	·720	·169	·770	·171	·736	·360
midn't	·815	·516	·978	·169	·716	·165	·765	·167	·728	·355

which gives the results derived from the hourly observations published in the Signal Service Report for 1873. Column 2d shows the mean height of the barometer at station 1 (summit of Mt. Washington), at each hour of the day for the month of June. Column 3d shows the mean height of the barometer at station 2 (5,553 feet above sea level); column 4th shows the barometer at station 3 (4,058 feet above the sea); and column

5th shows the barometer at station 4 (2,898 feet above the sea). Columns 6th and 7th show the mean height of the barometer at stations 1 and 4 for the month of May: columns 8th and 9th show the mean height of the barometer at stations 1 and 4 for the months of May and June combined. Column 10th shows the mean height of the barometer at each hour of the day for the month of August, on the summit of Mt. Mitchell, N. C. (elevation 6,691 feet), and column 11th shows the barometer at the base of the mountain (elevation 2,560 feet).

At the base of Mt. Washington the principal maximum occurs at 8½ A. M., but on the summit it does not occur until noon, being a retardation of 3½ hours, which is almost identically the same as we have found on page 7 by a comparison of the accidental fluctuations. At the base of Mt. Mitchell the principal maximum occurs at 8½ A. M., but on the summit it occurs at 10½ A. M., being a retardation of two hours, which also accords remarkably with the result derived on page 10, from the accidental fluctuations.

High Winds on Mount Washington.

In order to study the laws of the winds on Mount Washington, I selected from the published volumes of the Signal Service observations (Sept., 1872 to Jan., 1875) all those cases in which the velocity of the wind was at least sixty miles per hour. The number of these cases was 434, of which 117 occurred at 7.35 A. M., 137 at 4.35 P. M. and 180 at 11 P. M. Thus we see that at 11 P. M. the frequency of high winds is 42 per cent greater than at the other hours of observation. But near the level of the sea the force of the wind at 11 P. M. is generally near its minimum, so that we conclude that the causes which produce high winds on Mount Washington are mainly independent of the causes which determine the ordinary diurnal change in the force of the wind near the level of the sea.

The following table shows the average number of cases of violent winds for each month of the year.

Spring.			Summer.			Autumn.			Winter.		
Mar.	17.5	14.0	June	11.5	9.2	Sept.	11.7	13.8	Dec.	22.7	21.2
Apr.	15.5		July	6·5		Oct.	9.7		Jan.	21.3	
May	9.0		Aug.	9.5		Nov.	20.0		Feb.	19.5	

Thus we see that during the winter months, high winds are twice as frequent as during the summer months, while near the level of the sea high winds are seven times as frequent during the former period as during the latter period.

The following table shows the number of cases in which the wind blew from the different directions at the time of these high velocities.

North,	**53 cases.**	**South,**	**14 cases.**
Northwest,	**260 "**	**Southeast,**	**8 "**
West.	**63 "**	**East.**	**2 "**
Southwest,	**27 "**	**Northeast,**	**7 "**

Thus we see that 60 per cent of all the high winds came from the northwest; 75 per cent came from the west and northwest; 87 per cent came from the west, northwest and north; while only 4 per cent came from the northeast, east and southeast.

In order to determine whether these high winds bear a constant relation to centers of low pressure as indicated by observations near the level of the sea, I prepared a table showing for each date the position of the nearest center of low pressure. This table is so large that I have not thought it expedient to publish it entire, and I have endeavored to abridge it in such a manner as to give a correct idea of the contents of the complete table. In order to equalize the number of examples for the different directions of the wind, I adopted a different standard of velocity for each direction of the wind. For the northwest winds I have employed only velocities amounting to one hundred miles per hour; for the west wind, I have employed velocities of eighty miles per hour; for the north winds velocities of seventy-five miles; for the southwest winds sixty-five miles; for the south sixty miles; for the southeast, fifty-four miles; for the northeast, fifty miles, and for the east winds I have employed all velocities amounting to forty miles per hour. The results are shown in the following table, in which column 1st shows the number of reference, column 2d shows the date of observation; column 3d the direction of the wind, column 4th its velocity in miles per hour, column 6th the position of the nearest center of low pressure, and column 5th the height of the barometer at the station named.

It will be observed that with a north wind of seventy-five miles per hour on Mount Washington there was generally a low center near Halifax, Chatham, Sydney or Cape Rozier. In some cases the center of least pressure had already passed beyond our stations of observation. This remark applies to Nos. 1, 12 and 13. The direction of the wind was nearly at right angles to the direction of the low center. In all these cases the pressure was above thirty inches on the west side of Mount Washington and at a distance of five hundred or six hundred miles; but in a majority of the cases the center of high pressure was southwest of Mount Washington.

With a northwest wind of one hundred miles per hour on Mount Washington there was generally a low center near Halifax, Sydney, Quebec, Father Point or Cape Rozier. In the case of No. 33 (which is the continuation of No. 11) the low center had already passed beyond our stations of observation.

High Winds on Mt. Washington.

No.	Date.			Wind.		Low.	
				Direc.	Vel.	Bar.	Station.
1	’73.	Jan.	11.3	N.	76	29·95	Halifax.
2	’74.	April	4.3	N.	96	·45	Sydney.
3			11.3	N.	103	·69	Chatham.
4		Sept.	2.1	N.	80	·68	Sydney.
5		Oct.	16.1	N.	80	·77	C. Rozier.
6			19.3	N.	90	·37	Chatham.
7			20.1	N.	90	·56	Chatham.
8		Nov.	11.1	N.	78	·50	C. Rozier.
9			11.3	N.	80	·31	C. Rozier.
10			12.1	N.	76	·50	C. Rozier.
11			29.2	N.	84	·30	Chatham.
12		Dec.	12.2	N.	100	·95	C. Rozier.
13			12.3	N.	80		
14			15.2	N.	75	·75	Sydney.
15	’75.	Jan.	23.2	N.	96	·65	Sydney.
16			26.3	N.	98	·40	C. Rozier.
17			27.2	N.	98	·48	Halifax.
18	’73.	Feb.	10.2	N.W.	103	·56	Halifax.
19		Mar.	8.3	N.W.	126	·35	Quebec.
20		Aug.	16.3	N.W.	100	·63	Quebec.
21	’74.	Jan.	25.3	N.W.	126	·88	Halifax.
22		Feb.	5.2	N.W.	100	·67	Sydney.
23			8.1	N.W.	108	·62	Sydney.
24			11.2	N.W.	100	28·84	Sydney.
25		Mar.	20.3	N.W.	110	29·33	C. Rozier.
26			23.3	N.W.	130	·49	Sydney.
27			24.3	N.W.	102	·78	Sydney.•
28		Apr.	30.2	N.W.	130	28·97	Father Pt.
29			30.3	N.W.	115	·99	Father Pt.
30		June	12.3	N.W.	100	29·58	Quebec.
31			13.3	N.W.	108	·76	Sydney.
32		Nov.	5.3	N.W.	100	·64	Quebec.
33			30.3	N.W.	100		
34		Dec.	30.3	N.W.	100	·59	C. Rozier.
35	’75.	Jan.	9.3	N.W.	100	·28	Halifax.
36	’72.	Nov.	25.2	W.	85	·39	Quebec.
37		Dec.	10.3	W.	84	·73	Quebec.
38	’73.	Dec.	4.2	W.	80	·43	Quebec.
39			4.3	W.	96	·29	Chatham.
40	’74.	Jan.	23.2	W.	80	·32	Father Pt.
41			23.3	W.	108	·27	C. Rozier.
42			24.1	W.	88	·77	C. Rozier.
43		Feb.	25.3	W.	90	·47	Father Pt.
44		Mar.	24.2	W.	115	·67	Sydney.
45		June	8.1	W.	90	·45	Quebec.
46		Oct.	29.3	W.	92	·57	Montreal.
47		Nov.	5.2	W.	82	·67	Father Pt.
48		Dec.	14.3	W.	94	·28	Sydney.
49			18.1	W.	80	·18	Halifax.
50	’72.	Nov.	12.2	S.W.	65	·72	Montreal.
51		Dec.	21.3	S.W.	65	·88	Oswego.
52	’73.	Jan.	16.2	S.W.	74	·45	Buffalo.
53			16.3	S.W.	72	·36	Quebec.
54		Sept.	25.3	S.W.	65	·81	Montreal.
55		Nov.	27.2	S.W.	72	·55	Father Pt.
56		Dec.	4.1	S.W.	65	28·91	Marquette
57	’74.	Jan.	4.3	S.W.	80	29·55	Father Pt.
58			7.1	S.W.	65	·53	Ft. Garry.
59		Feb.	23.1	S.W.	82	·58	Rochester.
60		Mar.	3.3	S.W.	96	·33	Erie.
61			4.1	S.W.	74	·34	Ottawa.
62	’74.	Oct.	29.2	S.W.	68	29·49	Alpena.
63		Dec.	11.1	S.W.	70	·79	Ottawa.
64	’75.	Jan.	9.1	S.W.	73	·72	Parry Sd.
65			13.2	S.W.	65	·64	Parry Sd.
66	’73.	Jan.	5.2	S.	64	·45	Buffalo.
67			5.3	S.	60	·34	Oswego.
68			8.3	S.	66	·40	Marquette
69			13.3	S.	80	·68	Montreal.
70		Mar.	11.2	S.	77	·41	Montreal.
71			31.3	S.	82	·62	Portland.
72		April	9.3	S.	89	·47	Marquette
73	’74.	Apr.	20.2	S.	60	·40	Rochester.
74		May	16.1	S.	68	·55	Saugeen.
75			18.3	S.	60	·69	Quebec.
76		June	16.3	S.	60	·70	Ottawa.
77		Nov.	20.2	S.	60	·38	Portland.
78			28.3	S.	70	·85	Atlantic C.
79	’75.	Jan.	24.2	S.	60	·63	Buffalo.
80	’72.	Dec.	3.2	S.E.	60	·58	Quebec.
81			8·2	S.E.	54	·47	Montreal.
82	’73.	Mar.	20.3	S.E.	84	·36	Toronto.
83		Aug.	14.2	S.E.	60	·78	Lynchb’g.
84			14.3	S.E.	60	·82	Pittsburg.
85			18.2	S.E.	60	·90	Pittsburg.
86		Oct.	20.1	S.E.	75	·45	Cape May.
87			20.2	S.E.	78	·26	Philadel’a.
88			21.1	S.E.	55	·28	Erie.
89		Nov.	17.3	S.E.	56	28·82	Cape May.
90	’74.	Jan.	8.1	S.E.	62	29·32	Ottawa.
91		Sept.	17.3	S.E.	58	·56	Pembina.
92		Nov.	23.1	S.E.	54	28·75	Alpena.
93	’72.	Oct.	7.1	E.	45	29·83	Oswego.
94		Dec.	6.1	E.	42	·95	Quebec.
95	’73.	Apr.	12.3	E.	96	·51	N. London
96		May	3.2	E.	48	·58	N. London
97			9.2	E.	48	·61	Gd. Haven.
98		Nov.	18.1	E.	48	28·66	N. London
99			24.2	E.	58	29·27	Boston.
100	’74.	Apr.	10.1	E.	52	·49	Cape May.
101			25.3	E.	58	·32	Cape May.
102			26.1	E.	90	·13	Boston.
103		May	21.3	E.	50	·63	Portland.
104		July	4.3	E.	44	·72	New York
105		Sept.	29.3	E.	54	·24	N. London
106		Oct.	8.3	E.	50	·81	Barnegat.
107	’72.	Oct.	31.2	N.E.	50	·91	N. London
108			31.3	N.E.	72	·79	Portland.
109		Dec.	10.2	N.E.	62	·60	Quebec.
110			20.1	N.E.	55	·43	Buffalo.
111			20.2	N.E.	52	·50	Montreal.
112			28.1	N.E.	60	·49	Halifax.
113			28.2	N.E.	55	·81	Halifax.
114			28.3	N.E.	72	·94	Halifax.
115			29.1	N.E.	54		
116	’73.	Feb.	17.1	N.E.	60	·63	N. London
117			24.1	N.E.	52	·24	Quebec.
118		Apr.	12.2	N.E.	70	·52	New York
119			13.1	N.E.	58	·61	Boston.
120		Oct.	8.2	N.E.	50	·69	Halifax.
121			8.3	N.E.	60	·91	N. London

In twelve of the cases the stations which show the lowest pressure are the same as reported above for the north winds, but in six of the cases the lowest pressure was farther to the west. The average direction of the low center from Mount Washington was nearly at right angles to the direction of the winds. In all of these cases (except Nos. 28 and 29) the pressure was above thirty inches on the west side of Mount Washington and generally at a distance of about five hundred miles, but in a majority of the cases the center of high pressure was southwest of Mount Washington.

With a west wind of eighty miles per hour, the low center was generally near some one of the stations already named. In six of the cases the low center was near one of the stations named for the north winds; in twelve of the cases the low center was near one of the stations named for the northwest winds; and in one case (No. 46) the low center was farther west than was found for the north or northwest winds. The angle which the wind's direction made with the direction of the station reporting the least pressure ranges from about zero to somewhat over 90°. On account of the small number of stations, it is generally impossible to assign exactly the position of the center of least pressure, but apparently the angle which the wind's direction made with the direction of the low center was in some cases less than 45°. In all of these cases (except Nos. 45 and 47) the pressure was above thirty inches on the west side of Mount Washington and generally at a distance of about eight hundred miles; but in all cases the center of high pressure was somewhat south of west from Mount Washington.

With a southwest wind of sixty-five miles per hour, the direction of the station reporting the lowest pressure ranges from N. 25° E. to S. 75° W., the average direction of the low center making an angle of about 90° with the direction of the wind. In the case of No. 58 there was a low center in Virginia and a low center at the same time in Manitoba, and both seemed to exert an influence upon the direction of the wind on Mount Washington. In six of these cases the center of high pressure was southwest of Mount Washington, but in the remaining ten cases its direction was almost exactly west, and its distance about 1,300 miles.

With a south wind of sixty miles per hour on Mount Washington the low center is generally found nearly west from that station. The exceptions are Nos. 71, 75, 77 and 78. In the case of seventy-one we find the pressure at Montreal was less than at Burlington, so that it appears possible that at the height of 6,000 feet the center of least pressure was not over Portland but northwest of Montreal. In the case of seventy-five the pressure at Ottawa was only ·07 inch greater than at

Quebec; in the case of seventy-seven the pressure at Kingston was only ·02 inch greater than at Portland; and in seventy-eight the pressure at Albany was only ·05 inch greater than at Atlantic City; so that it appears not improbable that at the height of 6,000 feet the center of least pressure at each of these four dates was west of Mount Washington. In each of these cases there was a center of high pressure in a direction west or southwest from Mount Washington and at an average distance of 1,100 miles. It is presumed there was also an area of high pressure on the east side of Mount Washington, but it had already passed beyond our stations of observation.

With a southeast wind of fifty-four miles per hour on Mount Washington the low center falls between the directions south and northwest. The only exception is No. 80 and this case seems to indicate that at the height of 6,000 feet the low center was nearly two hundred miles in arrears of the low center at the surface of the earth. In each of these cases there was an area of high pressure west or southwest of Mount Washington. Generally its direction was nearly west and its distance about 1,200 miles. The center of high pressure on the east side had generally passed beyond our stations of observation, but in the case of No. 91, the pressure at Cape Rozier was 30·67 inches, and the distance of the center of low pressure was more than twice as great as usual.

With an east wind of sixty miles per hour the low center is generally found nearly south of Mount Washington. The exceptions are Nos. 93, 94, 97 and 103. In the case of Nos. 93 and 97, observations at other stations place the low center considerably south of Oswego and Grand Haven; and in the case of No. 103, observations at other stations place the low center west of Portland. The position of the areas of high pressure is nearly the same as for the southeast winds.

With a northeast wind of fifty miles per hour the low center is generally found south or southeast of Mount Washington. The exceptions are Nos. 109, 110, 111 and 117. In the case of Nos. 109 and 117 no observations were made near the Atlantic coast at any station east of Portland, and it is probable that at these dates the low center was not far from Halifax. In the case of Nos. 110 and 111 the low center came from the southwest, and the minimum of pressure on Mount Washington occurred fifteen hours later than at Burlington or Portland. It seems probable therefore that at the height of 6,000 feet the low center was considerably southwest of its position at the surface of the earth. In the case of No. 115 the low center had already passed beyond Halifax, which was the most eastern station of observation.

The examination of these one hundred and twenty-one cases seems to warrant the following conclusions: 1. High winds on Mount Washington circulate about a low center as they do near the level of the sea. 2. The motion of the wind is nearly at right angles to the direction of the low center. 3. The low center at the height of Mount Washington sometimes lags behind the low center at the surface of the earth apparently as much as two hundred miles.

High Winds on Pike's Peak.

In order to study the laws of the winds on Pike's Peak, I selected from the published volumes of the Signal Service observations (November, 1873 to January, 1875) all those cases in which the velocity of the wind was as great as thirty miles per hour. The number of these cases was 363, of which 136 were reported at 7.35 A. M., 97 at 4.35 P. M., and 130 at 11 P. M. Hence it appears that at 4.35 P. M. high winds are twenty-five per cent less frequent than at the other two hours of observation. But near the level of the sea the average force of the wind at 4 P. M. is double that at the other two hours, which results accord with the Mt. Washington observations in indicating that these high winds are mainly independent of the causes which determine the diurnal change at the level of the sea.

The average number of cases of violent winds for each month of the year is as follows:

Spring.			Summer.			Autumn.			Winter.		
March	14	15.7	June	21	11.3	Sept.	17	26.5	Dec.	28.5	31.2
April	17		July	2		Oct.	24		Jan.	42	
May	16		Aug.	11		Nov.	38.5		Feb.	23	

Thus we see that during the winter months high winds are nearly three times as frequent as during the summer months.

The following table shows the number of cases in which the wind blew from the different directions at the time of these high velocities.

North,	28 cases.	South,	18 cases.
Northwest,	47 "	Southeast,	1 case.
West,	154 "	East,	0 "
Southwest,	111 "	Northeast,	4 cases.

Thus we see that seventy-three per cent of these high winds come from the west and southwest, and only one per cent comes from any easterly point.

In order to determine whether these high winds bear a constant relation to centers of low pressure near the level of the sea, I have prepared a table similar to that on page 16. For the west winds I have employed all velocities amounting to fifty-five miles per hour; for the southwest winds I have employed velocities of fifty miles per hour; for the northwest winds velocities of forty-two miles per hour; for the north winds thirty-five miles per hour; for the south winds thirty-two miles per hour; for the northeast winds twenty-two miles per hour; for the southeast winds ten miles per hour, and for the east winds I have employed all velocities amounting to seven miles per hour. The following table is arranged in the same manner as that on page 16. For No. 47 the velocity of the wind is given seventy-seven miles according to the published observations; but I am informed by General Myers that this velocity should be thirty miles.

It will be observed that with a north wind of thirty-five miles per hour on Pike's Peak, there was generally an area of low pressure on the east side of that station. In the case of No. 11, throughout the entire United States the barometer was above thirty inches, but a low center was forming near Mobile which on the next day developed into a storm of considerable intensity. We also find that there was generally an area of high pressure in a direction west or northwest from Pike's Peak.

With a northwest wind of forty-two miles per hour, there was generally an area of low pressure on the northeast side of Pike's Peak. No. 23 is the same case as No. 11 noticed above. We also find that there was generally an area of high pressure on the Pacific coast.

With a west wind of fifty-five miles per hour, there was generally an area of low pressure in a northeast direction from Pike's Peak, and an area of high pressure on the Pacific coast. No. 40 is the same case as Nos. 11 and 23 noticed above.

With a southwest wind of fifty miles per hour, there was generally an area of low pressure in a northerly direction from Pike's Peak, and an area of high pressure on the Pacific coast or on the coast of Texas.

With a south wind of thirty-two miles per hour, there was generally an area of low pressure in a northerly direction from Pike's Peak. Frequently the center of low pressure appeared to be in a direction east of north. If there had been more westerly stations of observation it is presumed that in some of these cases the center of least pressure would have been found west of Bismark and Fort Sully. In the case of No. 73 an area of low pressure was forming near Pike's Peak, which became fully developed the next day. We also find that the pressure was generally somewhat above the mean in a direction southeast from Pike's Peak.

With a southeast wind of not less than ten miles per hour, there was generally an area of low pressure at no great distance, but in half of the cases the lowest observed pressure was on the northeast side of Pike's Peak. All but three of the cases occurred in summer, and the average velocity of the wind was only sixteen miles per hour. We also find that on the east side of Pike's Peak, the pressure was in each case a little above thirty inches.

High Winds on Pike's Peak.

No.	Date.	Wind.		Low.		No.	Date.	Wind.		Low.	
		Direc.	Vel.	Bar.	Station.			Direc.	Vel.	Bar.	Station.
1	'73. Nov. 17.3	N.	35	29·27	St. Louis.	62	'74. Apr. 12.1	S.	32	29·49	Ft. Sully.
2	18.2	N.	35	·23	Augusta.	63	May 27.3	S.	48	·24	Ft. Sully.
3	Dec. 26.1	N.	40	·41	Escanaba.	64	July 17.3	S.	32	·65	Ft. Sully.
4	26.3	N.	40	·48	Detroit.	65	Aug. 25.1	S.	40	·82	Salt Lk. C.
5	'74. Jan. 6.1	N.	40	·90	Montgom.	66	Oct. 22.3	S.	32	·82	Bismark.
6	May 2.3	N.	40	·35	Leavenw.	67	23.3	S.	40	·65	Salt Lk. C.
7	3.1	N.	36	·43	Leavenw.	68	24.1	S.	36	·66	Salt Lk. C.
8	Aug. 3.3	N.	36	·82	Ft. Sully.	69	24.3	S.	60	·24	Bismark.
9	Nov. 24.3	N.	55	·75	N. Orleans.	70	26.2	S.	40	·89	Salt Lk. C.
10	25.1	N.	35	·74	Jacksonv.	71	26.3	S.	50	·88	Salt Lk. C.
11	28.1	N.	35			72	27.3	S.	68	·64	Cheyenne.
12	Dec. 17.3	N.	40	·85	Santa Fé.	73	Nov. 15.3	S.	38		
13	21.3	N.	45	·62	St. Paul.	74	Dec. 14.2	S.	32	·87	Bismark.
14	23.2	N.	45	·49	Marquette	75	25.2	S.	40	·78	Salt Lk. C.
15	'73. Nov. 17.1	N.W.	65	·41	Duluth.	76	27.2	S.	32	·59	Bismark.
16	'74. Jan. 7.1	N.W.	42	·53	Ft. Garry.	77	'75. Jan. 15.2	S.	40	·70	Cheyenne.
17	8.1	N.W.	50	·42	Ft. Garry.	78	17.2	S.	42	·71	Cheyenne.
18	Apr. 13.1	N.W.	44	·30	Ft. Garry.	79	'74. Feb. 21.1	S.E.	24	·48	Santa Fé.
19	Sept. 16.2	N.W.	50	·54	Ft. Sully.	80	Apr. 17.1	S.E.	12	·59	Santa Fé.
20	Nov. 4.2	N.W.	44	·20	Bismark.	81	May 6.3	S.E.	30	·60	Salt Lk. C.
21	20.1	N.W.	46	·64	Breckenr.	82	June 21.3	S.E.	16	·68	Ft. Sully.
22	22.1	N.W.	65	·21	Breckenr.	83	22.2	S.E.	14	·44	Ft. Sully.
23	28.2	N.W.	55			84	28.3	S.E.	12	·71	Santa Fé.
24	28.3	N.W.	58	·85	Atlantic C.	85	July 2.2	S.E.	10	·45	Ft. Sully.
25	Dec. 9.3	N.W.	45	·74	Father Pt.	86	13.2	S.E.	16	·60	Ft. Sully.
26	28.1	N.W.	60	·73	Alpena.	87	17.2	S.E.	10	·60	Ft. Sully.
27	'75. Jan. 2.3	N.W.	42	·86	Cheyenne.	88	21.3	S.E.	12	·80	Pembina.
28	'74. Feb. 13.1	W.	60	·33	Detroit.	89	Aug. 8.2	S.E.	12	·72	Pembina.
29	Oct. 28.1	W.	60	·34	Omaha.	90	19.3	S.E.	24	·87	Portl'd, O.
30	28.2	W.	55	·28	St. Paul.	91	20.2	S.E.	12	·60	Ft. Sully.
31	Nov. 4.3	W.	60	·31	Bismark.	92	24.3	S.E.	28	·78	Salt Lk. C.
32	7.3	W.	56	·16	Duluth.	93	'74. May 30.2	E.	20	·86	San Franc.
33	8.1	W.	70	·34	Duluth.	94	June 30.2	E.	12	·81	San Franc.
34	8.3	W.	65	·68	Marquette	95	July 6.2	E.	16	·91	San Diego.
35	9.1	W.	60	·61	Bismark.	96	19.2	E.	8		
36	13.1	W.	62	·77	Bismark.	97	19.3	E.	28		
37	21.1	W.	60	·38	Bismark.	98	20.2	E.	8		
38	23.1	W.	75	28·75	Alpena.	99	Aug. 17.1	E.	12	·91	San Diego.
39	24.1	W.	65	·89	C. Rozier.	100	23.1	E.	8	·89	San Diego.
40	27.3	W.	55			101	23.3	E.	8	·87	San Diego.
41	Dec. 22.2	W.	55	29·39	Bismark.	102	Oct. 1.2	E.	11	·84	Salt Lk. C.
42	24.1	W.	60	·60	Alpena.	103	4.2	E.	7	·88	San Franc.
43	'75. Jan. 7.1	W.	62	·70	Cheyenne.	104	4.3	E.	12	·89	Portl'd, O.
44	9.2	W.	60	·72	Quebec.	105	14.2	E.	16	·97	San Franc.
45	19.3	W.	55	·68	Cheyenne.	106	'73. Nov. 18.1	N.E.	43	·81	Galveston.
46	'74. May 28.1	S.W.	55	·59	Breckenr.	107	18.3	N.E.	36	·85	Montgom.
47	June 1.2	S.W.	77	·75	Ft. Sully.	108	Dec. 12.2	N.E.	22	·67	Cairo.
48	10.1	S.W.	55	·68	Yankton.	109	24.3	N.E.	24		
49	27.1	S.W.	52	·50	Yankton.	110	'74. Feb. 6.1	N.E.	36	·93	Nashville.
50	Sept. 11.1	S.W.	55	·58	Ft. Sully.	111	Apr. 18.1	N.E.	24	·84	Galveston.
51	Oct. 24.2	S.W.	52	·23	Bismark.	112	July 7.1	N.E.	24	·81	Omaha.
52	27.2	S.W.	54	·76	Cheyenne.	113	7.3	N.E.	22	·78	Leavenw.
53	Nov. 6.1	S.W.	64	·30	Bismark.	114	8.2	N.E.	22	·56	Omaha.
54	6.2	S.W.	60	·28	Bismark.	115	27.3	N.E.	28	·82	Ft. Gibson.
55	13.2	S.W.	60	·53	Ft. Sully.	116	Sept. 8.2	N.E.	23	·84	Ft. Gibson.
56	Dec. 24.2	S.W.	65	·58	Ft. Sully.	117	23.2	N.E.	24	·84	Galveston.
57	24.3	S.W.	50	·50	Ft. Sully.	118	23.3	N.E.	28	·85	Shrevep't.
58	'75. Jan. 7.2	S.W.	62	·59	Cheyenne.	119	24.1	N.E.	36	·85	Shrevep't.
59	10.2	S.W.	50	·76	Cheyenne.	120	24.2	N.E.	22	·80	Shrevep't.
60	15.1	S.W.	54	·50	Cheyenne.	121	24.3	N.E.	22	·87	Ft. Gibson.
61	16.3	S.W.	55	·86	Cheyenne.						

With an east wind of not less than seven miles per hour on Pike's Peak, the pressure on the Pacific coast was generally somewhat less than thirty inches, while on the east side of that station the pressure was a little greater than thirty inches, but at Santa Fé the pressure at these dates was not sensibly below the mean. The average velocity of the wind was only twelve miles per hour. The majority of these cases occurred in summer, and none occurred during the colder half of the year.

With a northeast wind of twenty-two miles per hour, a pressure less than thirty inches was generally found on the east side of Pike's Peak, its average direction being about southeast. Also a pressure greater than thirty inches was generally found on the north or northwest side of Pike's Peak, but in half of the cases the difference between these two pressures did not exceed a quarter of an inch.

Comparing the preceding results with those before found for Mt. Washington, we see that with a high wind from the north, northwest, west, or southwest, the position of the areas of low pressure is similar at both stations, but the centers of least pressure are frequently more remote from Pike's Peak, and are more widely scattered This difference may be partly explained by the small number of stations east and north of Mt. Washington. With a high south or southeast wind on Pike's Peak the position of the low center is sometimes apparently east of north. Similar anomalies are sometimes noticed on Mt. Washington, but they admit of a plausible explanation. We also notice that with a low center at a given locality, the high winds on Pike's Peak may have a great variety of directions. Thus when there is a low center at Fort Sully, we find high winds on Pike's Peak from north, northwest, southwest, south, and southeast. When there is a low at Bismark or Cheyenne we find high winds on Pike's Peak from northwest, west, southwest and south. This result may be in part ascribed to the small number of stations near the Rocky Mountains, which renders it difficult to assign the precise position of the center of least pressure. It also appears that the direction of the wind on Pike's Peak depends partly upon the position of the areas of high pressure, but this direction seems to be influenced by circumstances which cannot be clearly assigned from the want of observations at a sufficient number of stations.

With an east or northeast wind on Pike's Peak, there is generally no low center of much magnitude indicated at any of the stations, and the average difference between the high on one side and the low on the other is only one-third of an inch. Hence we conclude that while high winds on Pike's Peak from the directions north, northwest, west and southwest indicate a circulation about a low center according to the same law as is observed near the level of the sea, the winds from the south, southeast, east and northeast give only obscure indications of being governed by this law.

The winds observed on Pike's Peak from the east and southeast are very few in number, particularly during the colder portion of the year. The following table shows the total number of easterly winds for each month during a period of three years from observations made three times a day.

	S.E.	E.	N.E.		S.E.	E.	N.E.		S.E.	E.	N.E.
Jan.	2	0	4	May	6	6	19	Sept.	5	4	36
Feb.	1	0	3	June	6	2	12	Oct.	2	9	19
Mar.	1	0	13	July	9	12	49	Nov.	1	0	10
Apr.	4	0	15	Aug.	7	8	25	Dec.	2	2	19

Thus we see that during the six months from November to April, an east wind was observed only twice in a period of three years. In one of these cases the velocity of the wind was six miles per hour, and in the other case three miles. The winds from east and southeast constitute less than three per cent of all the winds, whereas in the same latitude near the level of the sea the winds from these directions constitute twenty per cent of the whole number. We also notice that on Pike's Peak easterly winds are four times as frequent in summer as in winter, which seems to indicate that these winds are dependent upon difference of temperature more than upon difference of pressure. On the elevated plateau west of Pike's Peak are extensive regions where the temperature is as high as it is on the east side at a much lower level; whence it may result that at the height of Pike's Peak the temperature of the air on the west side is sometimes sensibly greater than it is on the east side.

The only station of the Signal Service whose direction is nearly south from Pike's Peak is Santa Fé. I have examined these observations to see what was the direction of the wind on Pike's Peak at the time of low barometer at Santa Fé. The following table shows all the cases in which there was a considerable depression at Santa Fé during the period of the published observations at Pike's Peak. Column second shows the date of the minimum; column third shows the lowest observation of the barometer; column fourth shows the direction and force of the wind at Santa Fé; column fifth shows the direction and force of the wind on Pike's Peak at the date named in column second; column sixth shows the wind on Pike's Peak at the time of the last preceding observation; and column seventh shows the position of the center of the nearest low area as shown by the observations.

Low barometer at Santa Fé.

No.	Date.	Santa Fe.		Wind on Pike's Peak.		Low.
		Bar.	Wind.	At date.	Prev. ob.	
1	'73. Nov. 22.2	29·51	Calm.	N.E. 20	Calm.	Ft. Gibson.
2	Dec. 2.2	·31	S.W. 26	S.W. 15	S.W. 20	Leavenworth.
3	7.2	·51	S.E. 8	S.W. 32	S.W. 18	Corinne.
4	'74. Jan. 2.2	·59	S.W. 6	S.W. 20	W. 40	Ft. Sully.
5	21.2	·38	S.W. 12	W. 10	W. 15	Cheyenne.
6	Feb. 12.2	·18	W. 24	W. 25	W. 16	Dubuque.
7	18.3	·39	S. 8	W. 8	S.W. 20	Ft. Sully.
8	21.2	·28	S.E. 12	S.W. 20	S.E. 24	Santa Fé.
9	24.1	·43	E. 12	S.W. 18	S.W. 16	Santa Fé.
10	Mar. 5.2	·26	S.W. 22	S.W. 12	S.W. 12	Cheyenne.
11	16.2	·18	S.W. 20	S.W. 16	W. 24	Ft. Sully.
12	30.1	·46	S. 16	S. 14	S.W. 20	Salt Lake City
13	April 6.2	·42	S.W. 30	S. 6	W. 15	Salt Lake City
14	12.2	·42	N.W. 20	N. 26	S. 32	Ft. Sully.
15	May 1.3	·41	W. 20	W. 24	S.W. 20	Leavenworth.
16	9.1	·44	S.W. 12	S.W. 20	S.W. 36	Ft. Sully.
17	Oct. 24.2	·59	S.W. 8	S.W. 52	S. 36	Bismark.
18	Nov. 3.2	·57	S.W. 8	S.W. 30	S.W. 40	Bismark.
19	21.3	·33	S.E. 12	S.W. 28	S.W. 32	Bismark.
20	26.2	·48	S.W. 4	W. 22	W. 20	Duluth.
21	Dec. 15.2	·55	S.W. 12	N.W. 26	W. 12	Ft. Sully.
22	21.1	·50	S. 8	N.E. 4	N.W. 10	Santa Fé.
23	27.1	·41	S.E. 4	S. 15	S.W. 20	Colorado Spr.
24	'75. Jan. 5.2	·42	Calm.	S.W. 15	S.W. 22	Cheyenne.
25	12.1	·35	S. 4	S.W. 1	S.W, 10	Salt Lake City
26	28.1	·41	N.E. 4	Calm.	W. 15	Corsicana.

We see that the center of low pressure generally passes north of Pike's Peak, and there are only six cases in which the low was south of Pike's Peak, viz: Nos. 1, 8, 9, 22, 23 and 26. In the case of Nos. 1 and 22 the wind on Pike's Peak was northeast; in No. 23 it was from the south; in No. 26 it was calm; in No. 8 it was southeast at the time of the last preceding observation; in No. 9 it was southwest and had been blowing from some western quarter for a period of forty-eight hours. The first five cases accord tolerably well with the results found for the winds on Mt. Washington, but No. 9 seems to indicate that the system of circulating winds which prevailed at that date at lower stations did not extend as high as Pike's Peak. We see that one reason why easterly winds are so rare on Pike's Peak, particularly during the winter months, is that the low centers generally pass north of that mountain.

The preceding investigation seems to warrant the following conclusions, which are an extension of those stated on page 19.

1. At the height of 6,000 feet the winds circulate about centers of low pressure as they do near the level of the sea, but frequently the position of the center of low pressure is sensibly different at the height of Mt. Washington from what it is at

lower stations, and we sometimes find low areas resulting from a circulation of the surface winds which does not extend to the height of 6,000 feet.

2. At the height of 14,000 feet the fluctuations of the barometer are quite large, but the centers of low pressure at this elevation differ in position from those at lower stations, so that frequently there appears to be but little correspondence between the movements of the wind on Pike's Peak and the fluctuations of pressure at the lower stations, and we frequently find areas of low pressure resulting from a circulation of the surface winds which does not extend to the height of 14,000 feet.

In preparing the materials for this article I have been assisted by Mr. Henry A. Hazen, a graduate of Dartmouth College of the class of 1871.

Art. II.—*Notes on the Mesozoic Strata of Virginia;* by Wm. M. Fontaine.

In this paper I present a summary of the results attained by a series of examinations, made in the Mesozoic strata of Virginia. These examinations have occupied the larger portion of my summer vacations for several years. Some of my conclusions were reached sometime ago, but as the field presents many difficulties in its study, and as I arrived at some unexpected results, I was not willing to present them until I had made repeated observations, and at remote points. As I have been very slow myself to reach some of these conclusions, I must expect that others will require convincing evidence before accepting them. Such evidence perhaps cannot be presented in the limits of an article. To deal fully with my material, whether stratigraphical, lithological, or derived from the fossil plants, will require an extended memoir. I hope soon to present this.

The great denudation which the Mesozoic beds and the enclosing crystalline or Azoic rocks have undergone, the proneness of the former to fall into a loose incoherent mass, the covering of drift matter and clay which often conceals the outcrops, all unite to render the task of studying the Mesozoic of Virginia a very laborious and difficult one.

It is due to Professor Wm. B. Rogers to state that his careful and accurate observations, made in the early surveys of Virginia, have rendered my work very much easier than it would otherwise have been; much that I have observed is merely a confirmation of what he had already noted. He has given correctly the location, boundaries and general character of the several Mesozoic areas, but as the relations of some of these do not seem to be understood, it will be necessary for me to give here some of these features with explanations. It will be understood, as was shown by Professor Rogers, that in Virginia the Cretaceous, if it exists, does not appear to view, hence the term Mesozoic includes only strata older than Cretaceous. In Virginia the Jurassic forms the youngest Mesozoic, and is overlaid by the Tertiary.

The several Mesozoic Belts.—The largest and most important Mesozoic belt is that which enters the State from Maryland, west of Washington, being the continuation of the tract so largely developed in New Jersey. For the sake of distinction it may be called the *New Jersey Belt.* It has all the features seen in its exposures farther north, and I have no reason to doubt its being of Triassic age. So far as can be ascertained from the scanty attainable evidence, it is in part, the oldest of the Virginia Mesozoic. It extends unbroken to the Rapidan River in Orange County, and has to the south, a few miles distant, a small outlier now separated from it owing to erosion.

A second narrow belt, a mere remnant which has escaped erosion, is found on James River, in the northern part of Buckingham County. This is now widely separated from the preceding belt, but possibly, though not probably, it once formed a part of it. This may be called the *Buckingham Belt.* A third narrow belt extends from the North Carolina border, near the Dan River, in a northeast direction through Pittsylvania into Campbell County. It has a width of four to eight miles, and a length of about thirty miles. Though now separated by a narrow interval from the Dan River Coal Field in North Carolina, it no doubt was once connected with it. This may be called the *Pittsylvania Belt.*

A fourth narrow belt extends northeast from Prince Edward into Cumberland County. It contains in its southern extremity a coal bed which is worked locally, and is the only belt except the Richmond Coal Field which contains any coal. This may be called the *Prince Edward Belt.* All of these four belts have many features in common. They have all suffered greatly from erosion. They have a northwest dip of varying steepness which extends unreversed across each belt. It is quite possible that the last two were once connected, but if so, it would seem to have been by narrow arms or inlets. Except in very rare cases these belts, and the enclosing Azoic rocks, have all been planed down to a uniform level. These four belts may be grouped as interior belts.

Passing to the east we find a fifth belt, nearly enclosed by Azoic rocks, but at its northern end touching later formations. This, which we may call the *Richmond Belt*, begins a short distance south of the Appomatox River in Amelia County, and extends in a direction a little east of north to the vicinity of Chesterfield Station, in Caroline County, on the Richmond, Fredericksburg and Potomac Railroad, where it is overlapped by later formations. On the Chickahominy River, northwest of Richmond, this belt is broken by an interval of Azoic rocks three miles wide, which separates the northern from the southern portions. The southern portion alone yields coal, and as it differs somewhat from the northern portion, we may give it the distinctive name of the Richmond Coal Field, while the northern portion lying mainly in Hanover County, may be called the Hanover area. No doubt the two were once connected by at least their latest formed beds. Both sections of the belt have suffered much from erosion, and we find here again the striking feature of the planing down of the yielding beds of the Mesozoic, to the same level with the most resistant Azoic strata. The coal field is separated from the Tertiary on the east by a belt of granite and gneissoid granite about twelve miles wide. This belt seems always to have formed the eastern border, cutting off the southern end of the coal field from communication with the open sea. It is by the sinking down of this granitic border to the north, that the Tertiary beds are enabled in that quarter to overlap the Mesozoic of the Hanover area. The northern end of the coal field proper sends finger-like projections into the Azoic, which are the deepest portions of troughs which have escaped erosion. Some of these are entirely isolated from the main field. They sometimes furnish very instructive sections, throwing light upon the geological history of the coal field.

Still farther east, and differing in position from all the preceding belts, we find two others geographically distinct, but geologically the same. These lie east of, and outside of the Azoic rocks, and are really a shore formation, which must have extended to the open sea, though the indications are that the communication was very imperfect. Owing to their apparent distinctness we must consider them separately.

The sixth belt, or the first of these border belts, begins at Petersburg and extends along the eastern edge of the Azoic rocks, in a direction almost due north, past Richmond to near the termination of the Hanover area, which it overlaps on its eastern side. In this quarter, the uppermost beds of the Hanover area appear to pass into the lowest of the belt in question, and both are overlaid by the Tertiary. It is quite possible that this belt, if it could be traced farther east, under the Tertiary, would be found to extend unbroken farther south. At any rate, Professor Rogers states that a small patch of strata of the same character is exposed in the bed of the Nottaway River in Sussex County, twenty miles south of Petersburg. In this direction the Tertiary strata overlap the Azoic, and bury the subjacent formations too deeply for the erosion of the streams to expose them, except in the locality mentioned. Professor Rogers, in his earlier reports, stated that an area of Mesozoic exists near Hick's Ford, but in his later reports, he states that the above-mentioned locality is the farthest point to the south at which the Mesozoic is found. I have not visited this place. South of the Nottaway, no traces of the Mesozoic have been seen. This belt may be called the *Petersburg Belt.* A seventh belt similar to the last is found nearly in the prolongation of it in a direction due north. This begins a little south of Fredericksburg and continues along the eastern border of the Azoic, in a northerly direction. Its western margin passes several miles west of Alexandria. As it passes out of the State it bends to the northeast, so as still to hug the eastern margin of the Azoic. So far as I have traced it, it extends at least as far north as Baltimore. This may be called the *Fredericksburg Belt.* Both the last mentioned belts always are found on the east of the Azoic, and are never seen invading it. In Virginia they dip eastward under the Eocene, and in Maryland under the Cretaceous. The dip is usually to some point in the southeast, and is very gentle. It is quite probable that these two belts are connected farther east, under the Tertiary, but along the margin of the Azoic they are separated by a considerable interval of the Tertiary, where this latter overlaps the Azoic. Geologically they form one area, which is very distinct from the Richmond belt. It is the relation of this border formation with the Richmond belt which is usually misunderstood. As we shall see, when we consider the character of the strata contained in them they differ greatly, and simply touch in Hanover County, where the different directions of the several areas cause them to meet at an acute angle. The statement made in the revised edition of Dana's Manual gives the usually accepted opinion. This statement is that the Richmond area begins on the Potomac, and extends south to the Appomatox River. I shall speak of these two belts as the border belts, and they are distinguished as the Petersburg and Fredericksburg belts as above stated. My studies of the Mesozoic in Virginia have been confined almost entirely to the border belts, and to portions of the Richmond belt, as these offered the most promising field.

The existence of all these belts, except the border ones, is due, I think, to the gradual depression of certain elongated tracts in the Azoic which have approximately the direction of the strike of the Azoic strata. The location of these depressed areas is fixed by the previous establishment of lines of weakness, by the processes producing the metamorphism of the

Azoic. The force producing the sinking along these lines was plainly a lateral thrust, which at least in the case of the Richmond belt, acted from east to west. The sinking seems to have commenced at or near the close of the Permian period, and to have continued till toward the close of the Jurassic. The depression was accompanied by, in many cases, extremely rapid sedimentation, and toward its end, produced a rupturing of the crust and an outpour of fused rock.

Wherever I have had an opportunity to examine carefully the Azoic rocks bordering the Mesozoic belts, I find them penetrated by dykes of true igneous matter, such as felsite, granite, diabase, etc., which are much older than the Mesozoic beds. These dykes run parallel with the Mesozoic belts, and are confined to their vicinity. Their presence indicates that in the general metamorphism of the country, fracturing of the crust took place, and the metamorphic action was excessive along certain lines. There is no doubt in my mind that this previous weakening of the crust in definite belts, has much to do with the subsequent emission of the Mesozoic trap rocks in such well defined areas as we find to exist. I find also here a good example of the application of Von Richthoven's conclusions concerning the order of precedence, and the association of igneous rocks.

Topography.—The topography of the Azoic, and the included Mesozoic areas, is very significant, and may be studied to great advantage in Virginia. What I shall say under this head is more particularly applicable to the district which is limited on the north by the Potomac, on the south by the Appomatox, on the east by the Tertiary, and on the west by the Catoctin range of mountains. I apply this, the Maryland name, to that more or less connected range which penetrates far into Virginia, under many different local appellations. It runs about fifteen miles east of, and nearly parallel to, the Blue Ridge.

The first thing that strikes the observer in this district is the very gently undulating character of the surface, which is so marked as to arrest the attention of the non-scientific, and to induce speculation as to the causes producing it. The country from the Catoctin eastward to the Tertiary, is a gently undulating plain, descending from about 500 feet in elevation to the level of tide. Unlike the country near the Blue Ridge, and farther west, the topography is almost uninfluenced by the structure and composition of the underlying rocks. In the area in question we have strata showing all gradations of hardness, with all degrees of proneness to decomposition, and dipping at various angles, often steeply, yet all are planed down to a uniform level. The streams, except the smallest creeks, cross the strike of the strata nearly at right angles, and are hardly at all guided or controlled in their courses by variations in the rocks across which they flow. They seem to be steadily deepening their channels, which work they have continued to perform, as it would seem, without noteworthy pause since their courses were first marked out.

The absence of any considerable inequality on the surface is well shown along the line of the Chesapeake and Ohio railroad, which runs between Richmond and Gordonsville, for fifty miles, directly across the strike of the various strata. In the area now in question the grades of the road are gentle, yet it turns aside for no hill, and has only one or two cuts which reach the depth of fifteen feet. Between the rivers, the country roads running east and west, pass over an almost uniformly level surface, of greater or less width, according to the distance apart of the principal streams. They are often almost devoid of water, as the smaller creeks rise in these levels, and flow north and south into the principal streams. There are many evidences showing that the level areas between the main streams are remnants of the original plane to which the country was cut down, and that the topography is entirely due to the action of the present system of streams in cutting down from this initial plane. Thus we find in the hill tops, and over the broader levels, certain clays and cobbles which occupy the same horizon always, and serve to fix the plane of this old surface. While peculiarities of erosion are shown in the character of some of the strata of the older Mesozoic belts, yet the principal denudation, and the most abnormal action, appear in the formation, and at the close of the deposit of the latest formed beds.

The condition of the surface of the Azoic rocks is also instructive. Those which admit of the formation and retention of smoothed and rounded forms, usually present such appearances. This is notably true of the granites and gneisses in the vicinity of Richmond.

The depth to which decay has penetrated here is far less than in the southern and southwestern parts of the State. In the latter we find strata not specially prone to decay, often decomposed, and changed to a loose earth, for fifty and even one hundred feet. This loose matter is suggestive of the way in which some of the later formed Mesozoic beds may have obtained their material, and its peculiar arrangement. This will be noticed later.

In the area of the Azoic with which we are now concerned however, the case is different. We rarely find the rocks decayed to as much as twenty feet in depth. Very often the surface clays rest on sound rock, or on that which is decomposed but a few feet below the surface. Again this decay has in nearly all cases taken place since the erosion above mentioned. We often find, resting on such decayed surfaces, large stones and gravel deposited at this period of general erosion, which shows that the decay could not have existed when these stones were deposited. All the facts point to the conclusion that in this northern Azoic belt, the agent which produced such extensive general denudation found, it is true, the Azoic deeply decomposed, and having its surface in the condition now found in the southern and southwestern part of the State, but it swept off all this loose granitic matter, and even reached the sound rock in many places. We may now turn to the consideration of some of the special features shown in the different belts.

The New Jersey Belt.—Of this I shall have little to say, except to call attention to certain remarkable deposits of stones on its western margin. The deposits of similar matter in the northern exposures of this belt are called conglomerates, and sometimes breccias. For the beds in Virginia these terms are inadequate. They are rather beds of bowlders. The northwest dip of the Mesozoic beds with which they are associated, and their position on the western side of the belt, show that if these deposits are contemporaneous with the other Mesozoic strata, they are the last formed. But in some cases at least it is not clear that the period of their deposition followed immediately that of the typical Mesozoic beds. These stones are found in unconnected deposits on the western edge of all the interior belts. In all these locations we find essentially the same features, the close agreement of which indicates that they are of the same or nearly the same age. In character these beds of stone differ much from the normal Mesozoic strata with which they are associated. These latter consist of sandstones and shales, well sorted and bedded by water action, and with their mineral constituents too much decomposed to betray, except in rare cases, the parent rocks. The case is different with the stones in question. They are of such large size, and the material is so fresh, that there is no difficulty in determining the precise character of the rock from which they were derived. Indeed the material is often as sound as if it had been taken from a quarry freshly opened. The material in nearly every case comes from rock found in place at a greater or less distance to the west. This distance is often many miles. The stones are usually imperfectly rounded, or subangular. They are packed in a fine, more or less argillaceous matrix, derived either from the erosion of the normal Mesozoic beds with which they are associated, or from comminution of their own substance. These deposits are often sharply distinct from the associated normal Mesozoic beds, and appear as if deposited in depressions in them excavated by erosion. But again they appear sometimes alternating with shales, and thus to form strata contemporaneous with the normal ones. The most common matrix enclosing the stones is red shale.

The most important, and by far the longest uninterrupted bed of stones, is that known under the name of the "Potomac Marble," or the "Limestone Breccia." This enters the State near Point of Rocks, Maryland. At Point of Rocks it is well exposed by the cuttings for the Metropolitan Branch of the Baltimore and Ohio Railroad. I examined the deposit at this place carefully to determine the character and origin of the stones. The stones here are all limestone. After long and careful search I found only one fragment not limestone. This was a slab about eighteen inches wide and four inches thick, of apparently Potsdam sandstone. In this vicinity the Azoic rocks are mica slates. Azoic limestone occurs some distance to the northeast, and may have furnished an impure pinkish limestone, which ranks third in the abundance and size of the fragments it has afforded. These are rarely over six inches in diameter and usually are under this size. The most abundant stones come from the dark bluish limestones of the Lower Silurian, which are not found south of Pennsylvania. This limestone gives fragments sometimes two feet, and often twelve or eighteen inches in diameter. A white marble which is highly siliceous, and shows on weathered surfaces a sandy character, is the second in abundance and in the size of the fragments, which are sometimes a foot in diameter. These stones are when large, subangular, when small, partially rounded. They are cemented by a fine grained red shale, apparently eroded from the adjoining normal Mesozoic red beds. This is rendered highly calcareous by an intimate mixture of it with finely comminuted limestone. The stones are firmly cemented by this, and the whole lies in massive ledges having apparently a northwest dip. This may however be only a false bedding. This formation, here about half a mile wide, extends far into Virginia, with a predominance of limestone fragments. Professor Rogers has shown that it extends unbroken as far as Warrenton, with a constantly diminishing amount of limestone. As this limestone must have come from Maryland and Pennsylvania, we see that some of the stones must have traveled long distances, viz: forty or fifty miles. The predominance of limestone is marked for some distance south of Leesburg.

A second deposit, not connected with the last, is well shown near Culpepper Court House, where I made a careful examination of it. This does not show any stratification, or limestone fragments, but consists of a mass of partly rounded and subangular stones, usually perfectly sound, and all packed in a fine-grained red shale, which binds the whole into an exceedingly firm and durable rock. The stones are composed of the characteristic rocks of the Blue Ridge, some twenty or twenty-five miles to the west, and northwest. They are commonly composed of a tough epidotic schist, subangular blocks of which, two feet by eighteen inches, and two feet by two and one-half, sometimes occur. The most abundant material is a compact chloritic schist which yields subangular stones two feet in diameter. By far the most common size, however, of all the stones, is from six to eight inches. Rocks yielding this material may be found nearer than the Blue Ridge, though none were seen in the immediate vicinity. Similar deposits are found at various other points on the west side of this, and the other interior belts. I will mention only one more, for the sake of illustration, and this occurs in the—

Pittsylvania Belt.—This deposit is remarkable for the great size and soundness of the stones, and for the complete contrast that it presents with the normal Mesozoic strata with which it is associated. These latter are here fine-grained red shales, dipping pretty steeply northwest. On the western edge of these, and apparently lying in a trough excavated by erosion in them, we find on George's Creek the bed in question. This was mentioned by Professor Rogers, on account of the large size of the stones. I made a careful examination of it. The most abundant and largest stones are composed of a coarse grained gneiss, which occurs in masses, sometimes hardly at all abraded, and up to four and five feet in diameter. Very commonly they are two and three feet in diameter. A fine-grained granite yields masses three and four feet in diameter, which show more abrasion. These occur with other material, all enclosed in a matrix composed of red shale, eroded from the normal Mesozoic, mingled with comminuted material similar to the large stones. All the large stones are remarkably fresh, and the whole mass is totally unlike anything seen elsewhere in this belt. The parent rocks yielding the stones may exist in the vicinity, though none exactly similar were seen in place. The normal strata of this belt may be divided into two series. The lower one contains predominant red and variegated shales, and red or brown sandstones. The sandstones often contain numerous, more or less angular, particles up to an inch or two in diameter, of the adjoining Azoic rocks, and commonly give evidence of rapid erosion and deposition. There is one very remarkable sandstone near the top of this series, which is composed almost entirely of feldspar. It consists of numerous partly rounded and slightly decayed particles of feldspar, with many perfectly fresh fragments of the same, showing brilliant cleavage faces. These are cemented by a felsitic paste into a firm rock, which can only by close inspection be distinguished from granite. It is difficult to see how such a rock could have been formed out of any of the Azoic rocks in the vicinity, for these contain a good deal of quartz, even when richest in feldspar, and this sandstone contains very little.

The upper series contains a predominance of reddish and dark bituminous shales and gray grits. Only faint traces of coal exist, in the form of thin films. No plant impressions were seen but some silicified wood occurs. The dip is northwest over the whole belt, varying from thirty to forty degrees. This constant high dip indicates a thickness for the formation which is not justified by the other indications. In the description of the Richmond coal field I will state what I think is the explanation of this apparent anomaly.

Deposits of bowlders similar to those above described appear, according to the statements of Emmons and Kerr, to be found associated with the Mesozoic of North Carolina. Emmons mentions beds of large stones as found on the west side of the Dan River coal field. There the normal strata dip northwest. Kerr mentions similar beds as occurring on the east side of the Deep River coal field, where the normal strata dip southeast. He however thinks that these stones come from the Azoic on the east, and attributes their transport to a pre-Triassic glaciation. I do not understand on what grounds Professor Kerr thinks that these beds are pre-Triassic, as he does not indicate any change of dip in the associated normal beds. This southeast dip and the position of the beds, would indicate that they are, as in Virginia, post-Triassic. Professor Emmons mentions that the Egypt shaft after passing through twenty-eight feet of soil (?) penetrated two feet of large stones, resting on the coal shales. This may be the same deposit with that of Professor Kerr. It does not seem possible that water action alone could have deposited these stones in their present position. For if we could conceive of a torrent of such power as to be able to transport these masses, and which would at the same time not remove the fine matrix in which they are imbedded, we should still be unable to understand how water could reach and remove material which had never been exposed, as surface rock, to the decomposing action of atmospheric agencies.

I will pass over the Buckingham Belt and the Prince Edward Belt, as I had no opportunity to study them, and will consider next the—

Richmond Coal Field.—This portion of the Richmond Belt, which, as previously defined, lies south of the Chickahominy River, is the only Mesozoic area in Virginia which shows the structure of a basin. The strata may be divided into two series, which show, as a whole, very marked differences, but between which no distinct line of separation can be traced.

The lower series, from three hundred to five hundred feet thick, rests immediately on the granitoid gneiss, which forms the floor of the basin. It contains all the coal found in the field. The number of coal beds is variable, but the most important are usually two or three in number, all contained within the space of about one hundred feet, and the lowest lying near the floor. In placing this coal-bearing portion next to the granite, I follow Rogers and Lyell, as their observations, which were more extensive than my own, show that the interval between the lowest coal beds and the granite is quite variable. The associated strata are usually flaggy sandstones, and more or less indurated shales, the material of all being so thoroughly sorted by water action and so completely changed that the parent rock cannot be recognized. The beds give proof of a good deal of disturbance in the presence of "slickensides," contortion, crushing and induration. Faults affect both this and the upper series, and suddenly collapsed anticlinals of small width occur, so that the dip is quite variable. As a rule the dip on the eastern side is westward and on the western side eastward, being steeper on the latter side, and the strata sometimes attain here a perpendicular position.

The upper series is perhaps not more than fifteen hundred feet thick, and differs in many points from the lower. The strata are mainly sandstones, sometimes coarse and conglomeratic, and as Rogers has shown, possessing the peculiar composition of a mixture of feldspar, quartz and mica, unsorted, and but little decomposed. They form a sort of granitic grit, which causes the rock to resemble granite. Subordinate beds of shale exist. This series shows less disturbance than the lower. The dip is more gentle, the beds are but little consolidated, or affected by crushing and rubbing. It contains no coal, and none except drifted, poorly preserved plants. The entire upper series shows marks of having been deposited in a rapidly sinking area, into which was poured an abundance of coarse matter, obtained by the rapid erosion of the surrounding granitoid rocks.

It is clear that much of the disturbance shown by the lower beds occurred during this sinking, which has also affected them with steeper dips than are found in the upper series. The lower beds were evidently deposited slowly, on a pretty stable area, which remained at the same level long enough for the important coal beds now found to be formed. The subsequent sinking seems to have been too rapid to permit the growth of sufficient vegetation to produce coal. Both series are penetrated by dykes of igneous rock. The rolls in the strata and the faults affect the structure of the field to such an extent that it is difficult to determine its depth, and determinations from shafts and borings cannot be relied upon absolutely. To illustrate this, I may mention two cases. Lyell states that the Midlothian (old) shaft was sunk within the field to the west of the previous workings, and entered the coal three hundred feet higher than was expected from the dip, thus giving an upthrow of this amount. This is on the east side of the field. On the west side at the Dover Mines, the company owning the works attempted to develop a new portion of the field by sinking a shaft a few hundred yards to the east of their old workings. They penetrated the entire series of strata, and found nothing workable.

My examination of some of the finger-like remnants of the Mesozoic, now found at the northern end of this field, thrust out in the Azoic, put me in possession of what I think is the explanation of the peculiarities of the structure of this field, and of the interior belts. The history of these areas, briefly stated, seems to be as follows:—

The strata were laid down in depressions, which, originally shallow, were subsequently deepened by a more or less rapid subsidence. The subsidence was due, as previously stated, to the operation of a lateral thrust. It continued until faults and overturned anticlinals were produced. In the interior belts these operated to produce a constant northwest dip. This resulted from the fact that the western sides of the severed earth prisms dropped, producing sometimes by a roll of the prisms an upthrow of the eastern side. This appears to occur in some of the faults of the Richmond coal field also. When the strain did not result in producing rupture and faulting, it caused the development of an anticlinal, affecting but a narrow belt, which was overturned to the eastward, thus producing also a continuous northwest dip. Where the strata have suffered enormously from erosion, and where almost precisely similar beds are formed by the similar conditions of deposition found repeated at different horizons, as is often the case in the interior belts, it is almost impossible to detect reduplications by faulting and folding. When the period of faulting was reached, eruptions of trap took place. It will thus be seen that the continuous dips would by no means give a true indication of the thickness of the series.

In the Richmond coal field the faults and narrow overturned folds are not of sufficient magnitude to produce, as in the interior belts, continuous dips, but suffice only to render very variable and uncertain the dip and position of the strata toward the center of the field. The general result seems to have been to flatten the dip here, and to steepen it on the western side. Some of the twists in the strata, produced by the overturned anticlinals, are of extremely limited extent. I have seen them only a few feet wide.

The direction, in which the lateral thrust operated in this field, was from east to west, and it seems not yet to be exhausted, for this region is often affected by minor earthquakes, and at intervals of ten or fifteen years, by very powerful ones, the last occurring a few years ago. The shocks pass from east to west. It is probable that the gradual depression of the coast is connected with this westward thrust.

Fossil Plants.—So far as known to me, the only plants from this field which have been published and described, are those made known by Rogers and Bunbury. Both of these authors considered the plants to be of the age of the lower Oolite of England. Most geologists, however, seem to agree in considering the beds yielding the plants, to be of the age of the Keuper, or Upper Trias. It must be borne in mind that only the lower, or coal-bearing portion, has yielded these plants.

Among European authors, Heer and Schimper are the only ones who, so far as I know, express an opinion concerning the age of the beds, based on an examination of the plants. I have not seen Heer's remarks, and hence do not know on what grounds he concludes that the plants are Triassic. Schimper, on page 277, vol. i, of his Pal. Veg., founds his belief in the Triassic age of the beds yielding the plants, both on the animal and plant life. I will consider only the latter.

He says, in speaking of the characteristic Equisetum of this field, which he calls *Equisetum Rogersii*, that it is nearer to *E. arenaceum*, the characteristic Equisetum of the Trias, than to *E. columnare*, the plant of the Lower Oolite with which Rogers and Bunbury thought it to be identical. He, however, only saw a cast of the interior of the Richmond plant. He says, farther, that this coal field has Pterophylla and Ferns, which have most affinity with the characteristic species of the Keuper. It does not appear from what source he derived this impression.

He is mistaken both concerning the Equisetum, and the other plants from this field. This Equisetum is next to *Macrotæniopteris grandifolia*, the most abundant and widely diffused plant of the field. I have beautifully preserved specimens, on a fine-grained shale, which shows with the utmost nicety the minutest details of the exterior of the plant. It is certainly so close to *Equisetum columnare* that, if separated, it can only be made, at most, a variety. The most abundant, widely diffused and characteristic plant, is *Macrotæniopteris grandifolia*, described by Rogers as *Tæniopteris grandifolia.* It is a curious illustration of the confusion existing in the minds of European writers concerning this coal field, to find that Schimper, in speaking of this plant, refers it to the *Oolitic* beds of the Richmond coal field, while he refers its constant companion, the Equiestum above mentioned, to the Keuper of the Richmond field. The fact is, that when both of these plants occur at a locality, they are so closely associated that they are confined to the same layer, from which they seem to exclude nearly all other species. Schimper also refers to the Oolite of the Richmond coal field, another plant often found associated with these two, viz: *Neuropteris linnæifolia* Bunb.

The *Macrotæniopteris* is allied more closely to the Oolitic *Macrotæniopterids* of England and India, than to any older plants. The nearest to it, among older plants, is the *Tæniopteris gigantea* Schenk, of the Rhætic. Nothing like it exists in the Trias. The *Pterophylla* of the Richmond beds belong to the Rhætic type, illustrated by *Pterophyllum Braunianum*, which type Schimper separates under the name of *Ctenophyllum*. These plants are very different from the Keuper type of true *Pterophylla*, as shown in *P. Jägeri* and *P. longifolium*. The plant which stands third in distribution and abundance, is one which I cannot distinguish from *Pterophyllum Braunianum*, which is a characteristic Rhætic plant, as given by Schenk.

The Ferns are either similar to Rhætic forms, or have an affinity with still later ones. I have fine specimens of a splendid Fern, which is allied to *Cyclopteris pachyrachis* Gœpp., though it is a smaller plant, and is a new species. From its association with *Neuropteris linnæifolia* Bunb., and the resemblance of the two, I think that it is the male form of Bunbury's plant. They are both allied to *Acrostichites Gœppertianus* Schenk, which is a Rhætic plant. I have also specimens of a fine Fern, closely allied to, if not identical with, *Asplenites Rösserti* Schenk, which is a characteristic plant of the Rhætic. Others might be mentioned, which show either Rhætic or Liassic, and even Oolitic affinities. I have not seen in this field a single Triassic plant.

In the revised edition of Dana's Manual, *Pecopteris* (*Lepidopteris*) *Stuttgartensis* Brongt., is given as occurring in this field. This statement is probably based on the identification by Heer, of this plant with Bunbury's *Pecopteris bullata*. I have seen nothing like *Pecopteris Stuttgartensis* in this field, but I have a number of fine specimens of a large Fern, which I take to be Bunbury's *P. bullata*. If they are not, then I have not seen this plant, though I have collected from the localities yielding it. My specimens show more of the character of the plant than Bunbury's, which, as is known, were very imperfect. It is certainly not *Pecopteris Stuttgartensis*. I have devoted more space to these Richmond plants than I would otherwise have done, because this flora is the oldest* of the Mesozoic of Virginia, and serves as a point of comparison for the plants found

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*** By this I do not mean that the beds containing this flora are the oldest of the Mesozoic strata in Virginia. The lowest strata of the interior belts have much in common, and are all, I think, Triassic. This is the oldest flora yet discovered.**

in the other belts. These plants all come from the lower series. As the result of my preliminary study of them, I conclude that the lower series is certainly not older than Rhætic, and if it be not Rhætic, then it is younger. Some may question the separation of the Rhætic from the Triassic. Whatever may be the evidence of the animal life of these two formations, the plants are different, and the Rhætic flora is rather to be reckoned with the Liassic than the Triassic flora. Schimper, Heer and Schenk, all show that the Rhætic flora contains no Triassic species.

[To be continued.]

ART. III.—*Discoveries of the United States Fish Commission: Notices of fifty species of east-coast Fishes, many of which are new to the fauna*; by G. BROWN GOODE and TARLETON H. BEAN.

THE object of the present paper is to give a brief summary of the coast investigations of the United States Fish Commission (Professor S. F. Baird, Commissioner) since the publication of a similar paper in this Journal for December, 1877, pp. 470–478. Certain species which should be mentioned here have not yet been identified; these will be reserved for a future paper. Full descriptions of species and discussions of questions hinted at in these notices have appeared or will appear in the Proceedings of the United States National Museum.

1. *Chilomycterus fuliginosus* (DeKay) Gill.

This species had been dropped by common consent from the faunal list; but after careful study of a specimen seined on Watch Hill beach, Rhode Island, September 12, 1874, we feel compelled to restore it.

2. *Hippocampus antiquorum* Leach.

Taken with a school of mackerel on George's Bank, August, 1873.—An addition to the fauna of the Western Atlantic.

3. *Glyptocephalus cynoglossus* (Linné) Gill.

The craig flounder abounds in deep water off the coast from Cape Ann to Halifax, occurring at a depth of thirty-five fathoms in Ipswich Bay, Massachusetts, and in Bedford Basin, Halifax Harbor, and seaward to a depth of 111 fathoms. Careful study of a large series of specimens has enabled us to unite with this species *Glyptocephalus acadianus* Gill and *Pleuronectes elongatus* Yarrell.

4. *Hippoglossoides limandoides* (Bloch) Günther.

Hippoglossoides dentatus (Storer) Günther, is apparently identical with this European species. The genus *Pomatopsetta* Gill, which was founded on Storer's *Pleuronectes dentata*, has no characters by which it may be distinguished from *Hippoglossoides*, and it should be set aside. *Hippoglossoides limandoides* is a deep water species found constantly with the preceding.

5. *Pleuronectes glaber* (Storer) Gill.

As a rule, the female may be distinguished from the male by its smooth scales, especially in the breeding season, and by its greater size. Gravid females were received from Salem, Massachusetts, January 10, 1878. The eggs are one-thirtieth of an inch in diameter. (Bean.)

6. *Ancylopsetta quadrocellata* Gill.

Of this species, which was described from Pensacola, Florida, and not elsewhere recorded, Professor S. F. Baird obtained two specimens in Charleston Market, South Carolina, April, 1877.

7. *Reinhardtius hippoglossoides* (Walb.) Gill.

The southern range of this Arctic species has been extended to latitude 42° N. Fishermen take them frequently in the gully between Le Have and George's Banks, at depths greater than 200 fathoms. They appear to inhabit the abrupt oceanic slopes of the banks beyond and below the range of the halibut; this fact, together with the uniform dark coloration of the under side of the body, seems to indicate that its habits differ from those of other pleuronectoid fishes.

8. *Chænopsetta oblonga* (Mitch.) Gill.

One specimen was trawled August 15, 1878, in the harbor of Gloucester. It has not previously been recorded in Massachusetts Bay except at Provincetown, where Captain Atwood obtained it in 1846, and where it has since been occasionally observed.

9. *Macrurus Bairdii* Goode and Bean.

The unique specimen of this species has been supplemented by three additional ones captured August 27, 1878, forty-two miles off Eastern Point Light (Cape Ann), E. $\frac{3}{4}$ S., in 175 fathoms, which is within two or three miles of the locality at which the type was secured.

10. *Macrurus rupestris* Bloch.

Many specimens have been brought in by fishermen whose testimony is that it is abundant in the deep waters on George's and the more northern banks.

11. *Phycis Chesteri* Goode and Bean.

Three specimens of a new species of *Phycis* were caught in the trawl-net thirty-three to forty-two miles E. by S. from Cape Ann in 110 to 140 fathoms. The largest measured

$0{\cdot}242^m$ (without caudal), the others $0{\cdot}143^m$ and $0\,142^m$: the latter were immature, and with the specific characteristics, particularly the length of the fin rays, not fully exhibited. The species may be characterized as follows. Head contained in length of body (without caudal) four and one-third times. Height of body in length five times. Diameter of orbit in length of head three and a half times, length of maxillary twice. Barbel one-third diameter of orbit. Vent in vertical from twelfth ray of second dorsal, and equidistant from tip of snout and extremity of second dorsal. Distance of first dorsal from snout equal to twice the length of mandible. Third ray of dorsal extremely elongate, extending to the thirty-third ray of second dorsal and two-thirds of the distance from snout to tip of caudal, its length more than twice that of the head. Anal inserted immediately behind the vent, at a distance from the ventrals equal to that of dorsal from snout. Ventral composed of three rays,* the first and second much prolonged, the first almost one-third as long as the body, the second three times as long as the head, extending to the fortieth ray of the anal fin and to a point three-fourths of the distance from snout to tip of caudal; the third shorter than the diameter of the orbit. Pectoral four times as long as the operculum. Scales large and thin, easily wrinkling with the folding of the thick flabby skin. Lateral line much broken on the posterior half of the body. Scales in ninety to ninety-one vertical rows and thirty-five horizontal rows, of which seven are above the lateral line. Radial formula: D., 9 or 10, 55 to 57. A. 56, C. 5, 18 to 21, 5. P. 17 or 18, V. 3.

The species has been named in honor of Captain H. C. Chester, well known as an Arctic explorer, and for four years attached to the United States Fish Commission.

12. ***Haloporphyrus viola*** Goode and Bean.

Two specimens of an undescribed species of the genus *Haloporphyrus* of Günther were brought in August 24, 1878, by Captain Joseph W. Collins of the schooner "Marion." They were taken on a halibut trawl-line on the outer edge of Le Have Bank at a depth of four or five hundred fathoms. The species may be briefly characterized as follows:

The head is contained four and one-third times in total length without caudal. The diameter of the orbit is one-fourth of the length of the head, or slightly more. The maxillary extends

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*A critical study of the ventral fins of *Phycis* leads us to believe that one of the accepted characters of the genus and of the sub-family *Phycinæ* is false, there being three separately articulated rays in each ventral. In the young of *Phycis chuss*, for instance, the short third ray is apparent, but in the adult it is hidden in the thick skin which envelopes the bases of the first and second rays, causing them to appear like "a single long ray bifid at the end."

to the vertical from the posterior margin of the orbit. The barbel scarcely equals half the diameter of the orbit.

The vent is situated under the nineteenth ray of the second dorsal, equidistant from snout and tip of caudal.

The anal is inserted behind the vent at a distance equal to the length of the second anal ray; it has a considerable depression in its middle and terminates in a line with the end of the second dorsal.

The pectoral is slightly more than four fifths as long as the head and extends to the vertical from the ninth ray of the second dorsal. Its length equals greatest height of body.

The longest ray of the ventral is about seven-eighths of the length of the head, and extends half way to the vent.

Radial formula: D. 4, 53; A. 40; V. 6. Scales in lateral line about 115; above lateral line 11.

13. *Hypsiptera argentea* Günther.

A single individual was taken at the surface, May, 1878, about forty miles off Cape May, New Jersey, by Captain Robert H. Hurlbert of Gloucester. This is an addition to the fauna of the Western Atlantic.

14. *Lota maculosa* (Le Sueur) Richardson.

After close study of a large series of specimens representing every locality from which species of *Lota* have been described in America and many places in Europe, Dr. Bean agrees with late writers in referring all the American species, so called, to *Lota maculosa.* This species, in the skeletons examined, has sixty-four vertebræ. The European variety, in two examples studied, shows sixty-one vertebræ. Dr. Günther gives the number as sixty. On the basis of this difference in the number of vertebræ Dr. Bean, for the present, separates the European from the American burbot as a variety with the name *Lota maculosa* (LeSueur) Rich. var. *vulgaris* Jenyns. Further observation of the number of vertebræ is very desirable.

The specific name *maculosa*, formed by Le Sueur in 1817, seems to have priority. Walbaum's *Gadus lacustris* was evidently a catfish.*

The name *vulgaris*, though attributed to Cuvier and Jurine was not used nor claimed until in 1835 by Jenyns in his Manual of the Vertebrate Animals.

15. *Lycodes Verrillii* Goode and Bean.

Taken sparingly in from 73 to 114 fathoms off Cape Ann, at one time within seven miles of Thatcher's Island.

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* See the description and also "Mathemeg" in Rich. Faun. Bor. Amer., p. 135, and Jordan, Bull. x, U. S. Nat. Mus., p. 84.

Professor Robert Collet* has considered this species identical with his *L. Sarsii;* but even the comparative tables which he introduces in support of this position show that the two species are clearly distinct.

16. *Leptoblennius serpentinus* (Storer) Gill.

Taken occasionally in seventy fathoms or more.

17. *Anarrhichas lupus* L.

Specimens of an *Anarrhichas* with brown cross bars instead of spots and which cannot in any way be distinguished from the European species, have been taken during the past season. We add this species to the faunal list without expressing an opinion as to the validity of the species *A. vomerinus* Agassiz.

18. *Eumicrotremus spinosus* (Fabr.) Gill.

Three specimens were secured, September 2, 1878, seventeen and three-quarter miles S. E. ½ E. from Eastern Point Light, Cape Ann, in twenty-three to twenty-eight fathoms.

19. *Trichidion octonemus* (Girard) Gill.

Of this species, hitherto known only from Texas, the United States National Museum has lately received a specimen collected by Mr. Silas Stearns at Pensacola, Florida.

20. *Orcynus pelamys* (Linné) Poey.

A specimen of the oceanic bonito was taken in July or August, 1877, off Provincetown, Massachusetts, and presented by Mr. Jas. H. Blake to the Museum of Comparative Zoology. An addition to our fauna.

21. *Caulolatilus microps* Goode and Bean.

A specimen two feet three inches in length, taken March 18, 1878, on the Snapper Bank, off Pensacola, Florida, in thirty-five fathoms of water, was received from Mr. Silas Stearns. For a full description see Proc. U. S. National Museum, 1878, p. 42.

22. *Cynoscion regalis* (Bloch) Gill.

Three individuals have been taken during the summer in Capt. Webb's trap near Thatcher's Island, off Cape Ann. It had not previously been recorded farther north than Provincetown, Massachusetts.

23. *Menticirrus nebulosus* (Mitch.) Gill.

One specimen was secured in the summer of 1878 by Captain Webb in the trap just referred to. Provincetown has been heretofore its recorded northern limit.

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* Fiske fra den norske Nordhavs—Exped. 1876–77, Christiania Vidensk.—Selsk. Forhandl. 1878, No. 4.

24. *Stenotomus argyrops* (Linné) Gill.

The northern range of the scup is extended to Thatcher's Island, off Cape Ann, where it has recently been taken in considerable numbers by Captain Webb.

25. *Sargus Holbrookii* Bean.

Six specimens of this new species, from Savannah Bank, were sent to the United States National Museum, March 29, 1878, by Mr. Goode. Numerous individuals apparently belonging to the same species were collected at Beaufort, North Carolina, by Professor D. S. Jordan during the summer of 1878.

Diagnosis: Body ovate, compressed, a very slight protuberance above the upper anterior margin of the orbit, and a very marked one in the supra-occipital region. Distance from origin of ventral to origin of spinous dorsal is about two-fifths of total length to end of middle caudal rays.* Least height of tail is about equal to length of upper jaw.

Length of head is contained three and three-quarter times in total. The interorbital area is slightly less than one and a half times the long diameter of eye. The length of snout is one-tenth of total length and about equals that of mandible. The eye is contained nearly four and one-fifth times in length of head.

The longest dorsal spine is contained from eight and one-half to ten times in total length of body.

The distance of anal from snout is contained one and five-eighth times in total length. Longest anal spine equals one-twelfth of total length.

The length of middle caudal rays equals that of snout.

The distance of pectoral from snout is contained three and one-half times, and its length about three times in total length.

The distance of ventral from snout slightly exceeds the length of pectoral. Length of ventral averages nearly one-fifth of total length.

Radial formula: B. vi; D. xii, 13–14; A. iii, 13–14; P. 15–16; v, 1, 5.

Scales: 8–60 to 62–16.

Teeth: eight incisors in each jaw, their greatest width equal to half their length. Three rows of molars above, two below, with sometimes a tendency to increase the number of rows.

For a full description, see Proc. U. S. National Museum, 1878.

26. *Rhomboplites aurorubens* (Cuv. and Val.) Gill.

A specimen of this species, hitherto known only from the West Indies was secured in May from Mr. C. C. Lesley, of

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* This length is the basis of comparison for all my measurements of this species.

Charleston, South Carolina, another was collected at Pensacola, Florida, by Mr. Silas Stearns a few days later.

27. *Lutjanus Blackfordii* Goode and Bean.

The "red-snapper" of the Southern Atlantic and Gulf coasts proves to be distinct from the West Indian species with which it had previously been confused. It was named in honor of Mr. E. G. Blackford of New York City, a gentleman who has rendered many important services to American ichthyology. Full descriptions of this and the following species may be found in the Proceedings of the U. S. National Museum.

28. *Lutjanus Stearnsii* Goode and Bean.

The "mangrove snapper" of the Gulf of Mexico proved to be new and was named in honor of Mr. Silas Stearns of Pensacola, by whom the only known specimen was collected. *Rhomboplites aurorubens*, mentioned above, is known at Charleston as the "mangrove snapper," at Pensacola as the "bastard snapper."

29. *Epinephelus Drummond-Hayi* Goode and Bean.

This magnificent species was first discovered at the Bermudas in 1851, by Col. H. M. Drummond Hay, C.M.Z.S., by whom a sketch and partial description were prepared. The National Museum has lately received two specimens from Florida, one from Mr. Blackford, collected at the Keys, the other from Mr. Stearns at Pensacola. The species attains the weight of fifty pounds or more.

30. *Epinephelus niveatus* (Cuv. and Val.) Poey.

This species has been taken twice at Newport, Rhode Island, by Samuel Powel, Esq. The first specimen, a young individual, was made the type of the genus *Hyporthodus** by Professor Gill. A comparison of *Hyporthodus flavicauda* Gill with Cuban specimens of *Epinephelus niveatus* proves their identity. The second specimen was received from Newport in 1877. It has not been recorded elsewhere on the East coast.

31. *Roccus lineatus* (Bl. Schn.) Gill.

The "rock-fish" is taken in winter in the Altamaha River, in considerable numbers. South of this region its occurrence is extremely rare. Two were observed in the St. Johns River, Florida, in 1874; and in May, 1878, a stray individual was sent by Mr. Stearns from Pensacola.

32. *Remoropsis brachyptera* (Lowe) Gill.

Two specimens of this rare species have been obtained from fishing schooners. One was found clinging to the side of a sword-fish harpooned in the channel southwest of George's Bank, another on the deck of a halibut-trawler fishing in the gully northeast of George's Bank, at a time when sword fish were being taken on the trawls. This species may very probably be a parasite peculiar to *Xiphias*, as the allied species, *Rhombochirus osteochir* is to *Tetrapturus albridus.*

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* Proc. Acad. Nat. Sci. Philad., 1861, pp. 98–99.

33. *Belone latimanus* Poey.

The occurrence of a single specimen of this West Indian form in Buzzard's Bay, where it was obtained by the Commission in 1875, has already been recorded (Proc. U. S. National Museum, i, 1878, p. 6.) Several additional specimens from North Carolina or Chesapeake Bay, were obtained in Fulton market, New York, June 1, 1878.

34. *Belone hians* Cuvier and Valenciennes.

In company with the preceding were several specimens of this species hitherto recorded only from Bahia, the West Indies, and the Bermudas.

35. *Fundulus seminolis* Lesueur.

This species, long lost sight of, was collected in quantity by Professor Baird on the upper St. Johns River.

36. *Lucania parva* (Baird and Girard) Bean.

The *Cyprinodon parvus* of Baird and Girard should be referred to the genus *Lucania* Girard. The species is recorded only from Beesley's Point, New Jersey, Sinepuxent Bay, Maryland, Greenport, Long Island and Noank, Connecticut. (Bean.)

37. *Alepidosaurus ferox* Lowe.

Six specimens of this species are now on record in the United States—one in the collection of the Boston Society of Natural History and five in the United States National Museum. All of these have been captured within the limits of lat. 41° and 44° and at depths of 200 to 400 fathoms.

The first capture of *Alepidosaurus* in the Western Atlantic, was by Captain D. C. Murphy of the schooner Centennial in July, 1877, in 200 to 300 fathoms. Lat. 43° 46′ N.; long. 59° 19′ W.

38. *Salmo salar* L.

The salmon has been transported by the Commission of Fisheries to the rivers of the Middle States, to many points in the Mississippi valley and to the California coast. It may be regarded as acclimated in the Hudson, Delaware and Susquehanna Rivers, and re-acclimated in the Connecticut.

39. *Brevoortia tyrannus* (Latrobe) Goode.

The common menhaden was described under the name *Clupea tyrannus* by Latrobe in 1802, and the specific name then proposed has priority over all others. An extended study of the species of this group indicates that the *B. tyrannus* occurs on the coast of Brazil, as far south as Bahia, and that Spix's *Clupanodon aureus* is specifically identical and should be included as a subspecies, *B. tyrannus* subspecies *aurea.*

40. *Brevoortia patronus* Goode.

A species occurring at several points on the north shore of the Gulf of Mexico, from the mouth of the Rio Grande to Pensacola, Florida, where Mr. Stearns observed it in great abundance.

41. *Alosa sapidissima* (Wilson) Storer.

Through the agency of the United States Commission of Fisheries the common shad has been introduced into most of the rivers flowing through the Southern States into the Gulf of Mexico, and may now be considered a member of the fauna of that region, its range south and west having been extended over at least twelve hundred additional miles of coast line. It is also acclimated in California.

42. *Pomolobus pseudoharengus* (Wilson) Gill.

Abundant in Lake Ontario, Cayuga and Seneca Lakes, New York. The variety *lacustris,* founded on Cayuga Lake specimens by Professor Jordan, is precisely like the average coast alewife. After careful measurements of numerous lake and coast specimens I am unable to separate them. (Bean.)

43. *Nemichthys scolopaceus?* Richardson.

A single specimen nineteen inches long, of a curious eel-like fish was obtained from a fisherman who took it, living, from the stomach of a cod fish caught on George's Bank in February, 1875, in forty-five fathoms. Another, preserved in the collection of the Cape Ann Literary and Scientific Association at Gloucester, was picked up on the deck of a cod vessel. It belongs to the genus *Nemichthys* described by Sir John Richardson from a specimen collected by the exploring ship Samarang in the South Atlantic. Only one species has been described, the type was from the South Atlantic. Another specimen of the genus was taken at Madeira and described by Lowe under the name *Leptorhyncus Leuchtenbergii.* Günther considers it to be identical with *N. scolopaceus.* The American fish is at present assigned to the same species. The family *Nemichthyidæ* is new to the Western Atlantic.

44. *Amia calva* L.

The range of the mud-fish has not hitherto been recognized to extend south of Charleston, South Carolina, whence Garden sent specimens to Linnæus. It occurs abundantly in the St. Johns River, Florida, and Mr. S. C. Clarke found it in Spruce Creek, a tributary of Halifax River, about lat. 28°.

45. *Chimaera plumbea* Gill.

Within the past twelve months seven individuals have been secured—one by the Boston Society of Natural History and six by the United States National Museum.

The first specimen was taken by Captain D. C. Murphy of the schooner Centennial in July, 1877, in 200 to 300 fathoms, lat. 43° 46′ N., long. 59° 19′ W. Others have since been taken within the latitudes 42° and 44° N. and in water from 200 to 350 fathoms deep.

46. *Torpedo occidentalis* Storer.

Taken occasionally near Thatcher's Island, off Cape Ann, by Captain Webb, in his trap. A specimen was taken at Lanesville, Massachusetts, July 13, 1878, the only instance of its occurrence to the northward of the point of Cape Ann.

47. *Hypoprion longirostris* Poey.

A West Indian species; collected in the Gulf of Mexico, by Dr. J. W. Velie, of Chicago, and sent to Washington for identification.

48. *Centroscymnus cœlolepis* Bocage and Capello.

This species was described from the coast of Portugal. It is recorded, also, from Madeira. Three specimens were presented to the United States National Museum, August 26, 1878, by the crew of the schooner Marion, who captured them on the Nova Scotia banks, the first specimens known from the Western Atlantic.

49. *Centroscyllium Fabricii* (Reinh.) Müller and Henle.

A Greenland species. One individual was received from Captain Jos. W. Collins, schooner Marion; locality same as the last. This species is new to the fauna of the Western Atlantic. Both this and the preceding are called by the fishermen "Black Dog fish."

50. *Ginglymostoma cirratum* (L. Gm.) Müller and Henle.

An adult specimen was taken in the Gulf of Mexico, by Dr. J. W. Velie of Chicago. A young individual was captured by Mr. Otto Lugger in Chesapeake Bay.

Gloucester, Mass., September 7, 1878.

ART. IV.—*Note on the Brightness and the Stellar Magnitude of the third Saturnian satellite*—Tethys; by EDWARD S. HOLDEN.

[Communicated by permission of Rear Admiral JOHN RODGERS, U. S. N., Superintendent U. S. Naval Observatory.]

ON November 20, 1878, I was observing *Saturn's* satellites with the 26-inch refractor, using an eye-piece magnifying 400 diameters. Four satellites were nearly in the plane of the ring (position angle 94°·2). They were

Tethys; $p=265°$, $s=35''$; (estimated.)
Dione; $p=94$, $s=60''$; (")
Titan; $p=94\pm$, $s=$ over $150''$ (estimated.)
Enceladus; $p=92$ (est), $s=31''\cdot13$ (measured.)

At about $8^h\ 30^m$ as I had just completed the measure of the distance of *Enceladus*, the sky became covered with flying clouds, which continually passed over *Saturn*, partially obscuring the planet and dimming the light of the satellites. The clouds were probably forming and disappearing constantly, as the air was full of moisture, the difference of the wet and dry bulb thermometers being less than 1° F.

I had noticed before beginning to observe that large portions of the sky were alternately obscured and clear, evidently owing to thin clouds formed on the spot.

The disappearance or dimming was gradual and it seemed suited to a photometric experiment similar to that tried by Bond on the nebula of *Orion* during twilight, when the order of the appearance of the details, with the times, were noted.*

Accordingly, Mr. Anderson, assistant, watched *Saturn* with the naked eye, looking along the telescope as a guide at the planet, while I watched the appearance of the satellites through the equatorial. The interior of the dome was perfectly dark.

As a cloud gradually (and as nearly as could be judged uniformly) darkened *Saturn* as seen in the telescope, the appearances were carefully noted and when the planet disappeared to the naked eye Anderson called "now."

At this instant I endeavored to note the visibility of the satellites.

Enceladus, which was faint at the best, always disappeared before this instant. In four (tolerably satisfactory) experiments it was found that *Tethys* disappeared in the telescope at the same instant that *Saturn* did to the naked eye. In several reappearances I found that *Dione* reappeared in the telescope just before *Saturn* appeared to the naked eye; and that *Tethys* was seen almost at the same time, or a very little after this. When *Saturn* was just appearing or disappearing *Titan* was as bright in the telescope as *Dione* when no clouds were present.

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* Annals Harv. Coll. Obs., vol. v, p. 164, etc.

Dione was always a little brighter that *Tethys.* The southern edge of the belt in the southern hemisphere of *Saturn* vanished *about* at the same time as *Enceladus.* This observation is, however, not so precise as those on *Tethys.*

As many appearances and disappearances as possible were observed and the result of them all is that *Tethys* was as bright to my eye in the telescope as *Saturn* was to Anderson's unassisted eye. It may be mentioned that Anderson under good circumstances can see *Uranus* with the naked eye, and by experience I have learned that my eye is well suited to seeing faint satellites like those of *Uranus* and *Neptune.* I believe that our eyes used as in this experiment were as nearly equal as any could be.

The sky became totally cloudy before I could measure the the position of *Tethys.* From Prof. Newcomb's MS. tables the time of West elongation is $12^h.4$ Wash. m. t.

These experiments enable us to determine approximately, the relative brilliancy of *Tethys*, in this part of its orbit, with *Saturn.* Assuming the diameter of the pupil of the eye at $0{\cdot}2^{in}$ the relative amount of light received by Anderson's eye from *Saturn* and through the telescope from *Tethys* are as $(26{\cdot}00 \text{ inches})^2$ to $(0{\cdot}2 \text{ inches})^2$, or as 16,900 to 1. So that the immediate result of these experiments is that *Tethys* was at that time $\frac{1}{16900}$th part, or 0·00005917 as bright as *Saturn*, including both ball and ring.

From the table given by Zöllner in *Photometrische Untersuchungen*, p. 200, it follows that if *Saturn* had been without his ring, the light from the ball alone would have been 0·9356 (log. 9·9711) of the light of ball and rings combined. Hence if H_1 is the light from the ball alone, the light received from *Tethys* was $\frac{1}{16,900} \cdot \frac{H_1}{0{\cdot}9356} = 0{\cdot}00006323.\ H_1$ (log. $5{\cdot}8009\ H_1$).

If H_1 is the brilliancy of a planet at a time when its distance from the sun is r_1 and from the earth ρ_1; and if d is the true diameter of the planet in miles and A a constant depending on the nature of its reflecting surface then

$$H = A.d^2\left(\frac{1}{r_1^2.\rho_1^2}\right)^*$$

At another time, $H_2 = A.d^2.\left(\frac{1}{r_2^2.\rho_2^2}\right)$ and

$$H_1 : H_2 = r_2^2\,\rho_2^2 : r_1^2.\rho_1^2.$$

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* **See Stampfer: Sitzungsber. der k. Acad. d. Wiss. Berlin, vol. vii, 1851, p. 760.**

For November 20, $8^h.5$ Wash. m. t., log. r_1 = 0·9787 and log. ρ_1 = 0·9554. The mean distance of *Saturn* is 9·5389 (log. r_2 = 0·9795) and the log. of its mean distance from the earth is log. ρ_2=0·9789. Thus the brilliancy of *Saturn* was greater on November 20 than at its mean opposition in the ratio of 1·118 to 1, or $H_1 = 1·118\ H_2$. Thus *Tethys* = 0·000071 H_2 or in words, *Tethys in this particular part of its orbit has seventy-one millionths of the brilliancy of the ball of Saturn at mean opposition.*

Zöllner has determined (op. cit. p. 145) the relative brilliancy of *Saturn's* ball at mean opposition of *Capella* to be *Saturn* = 0·431 *Capella*; (log. 9·6345). Hence *Tethys*=0·000030 *Capella*; (log. 5·4840).

From this we can determine the stellar magnitude of *Tethys*.

If the light of a first magnitude star (as *Capella*) be assumed as 1·000 and if the light-ratio be δ (0·40) and if m be the magnitude of the star on Argelander's scale, then δ^{m-1} = the light of the star in terms of the light of the first magnitude star as unity. For us δ^{m-1} = 0·000030 or m = 12·3 approximately. [On Struve's scale m' = 11·8. On Herschel's scale m'' = 12·5.]

The resulting stellar magnitude of *Tethys* on Argelander's scale being as we have seen 12·3 it should be just visible with a telescope of a little over four inches aperture.* This I tested on November 23d, and I find that with four inches aperture *Tethys* was just barely visible at elongation (East) with a power of 200 diameters when *Saturn* was in the field. When *Saturn* was put out of the field it was just steadily visible. With a power of 400 it was better seen, never totally disappearing. With an aperture of five inches on the finder and a power of thirty it was not seen. The appearances were the same to both Anderson and myself. These observations give a rough check on the preceding accurate ones, as the two methods agree better than could be expected. It also affords some evidence as to the eyes of the two observers.

If the relative brilliancy of the various satellites among themselves be measured, the foregoing observations afford a ready means of deducing their brilliancy in terms of a standard star like *Capella* and hence in terms of any standard star.

U. S. Naval Observatory, Washington, 1878, Nov. 25.

*** See Pogson: Mon. Not. R. A. S., vol. xxi, p. 34. It is important to remember that in the application of Pogson's formula there is considerable uncertainty owing to the varying effects of different magnifying powers, and to other causes.**

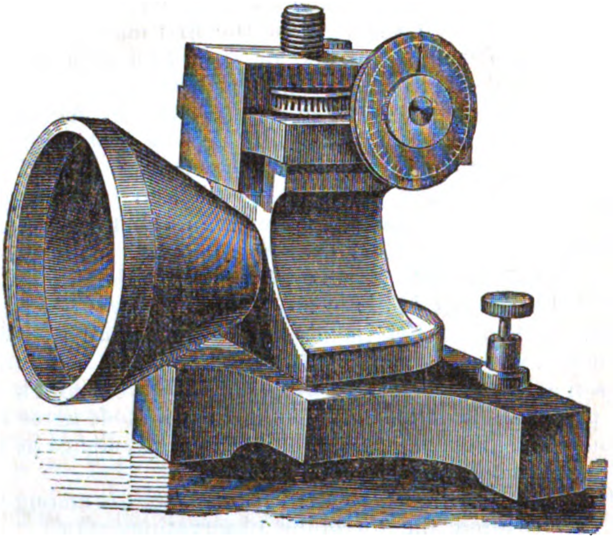
ART. V.—*On the use of the Tasimeter for Measuring the Heat of the Stars and of the Sun's Corona*;* by THOMAS A. EDISON, Ph.D.

To Professor Henry Draper M.D., Director of the Draper Eclipse Expedition:—

Dear Sir: The instrument which I used at Rawlins, Wyoming, during the solar eclipse of July 29, 1878, for the purpose of measuring the heat of the sun's corona, was devised by me a short time only before that event; and the time was insufficient to allow me to give it as thorough a test as was desirable to ascertain its full capabilities and characteristics.

This instrument I have named the tasimeter, from the Greek words *τασις*, extension, and *μετρον*, measure, because primarily the effect is to measure extension of any kind. The form of instrument which I used is shown in the annexed wood-cut (fig. 1.)

1.



With this instrument was used a Thomson's reflecting galvanometer, on a tripod, and having a resistance of three-fourths of an ohm. The galvanometer was placed in the bridge wire of a Wheatstone balance, two of the branches of which had constant resistances of ten ohms each, while of the other two one had a constant of three ohms, and the other contained the tasimeter which was adjusted by means of the screw to three ohms. When thus balanced if the strip of vulcanized rubber placed between the fixed point and the carbon button (seen in fig. 2) was exposed to heat from any source, it expanded, producing pressure upon the carbon button, decreasing its resistance and destroying the balance; a current was thus allowed to pass through the bridge wire containing the galvanometer, the amount of this current of course being proportional to the expansion of the rubber and to the strength of the battery.

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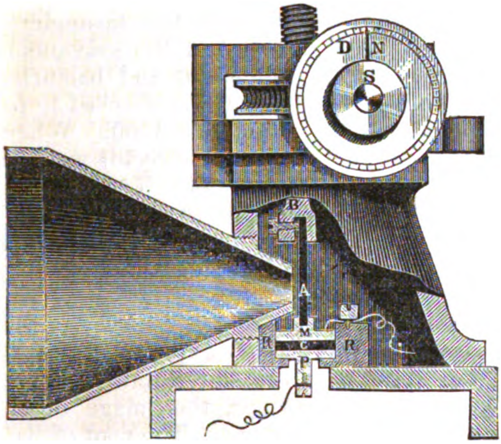
* Read, by permission of Dr. Draper, at the St. Louis meeting of the American Association.

2.



The form of instrument here described was only finished two days before leaving for the west; hence I was unable to test it. However, I set it up upon my arrival at Rawlins, but found that it was a very difficult matter to balance so delicate an instrument as a reflecting galvanometer with one cell of a battery, through such small resistances. In fact, I did not succeed in balancing it at all in the usual way. Nor could it be balanced in any way until I devised a method which I may designate "fractional balancing," when it became very easy to accomplish the result and also to increase the effect by using two cells in place of a single one. This device consisted of a rheostat formed of two rows of pins. The rows were about one-half an inch apart. A wire was connected from a pin on one row to a pin on the other row and so on, so that the current had to pass through the whole length of the wire, which was No. 24 gauge and four feet long. This was used as a shunt around the galvanometer. A copper wire connecting all the pins of one row served to reduce the resistance to zero. When the galvanometer was then shunted, a very feeble current passed through it. If the spot of light was not at zero it was brought there by either increasing or decreasing the pressure upon the vulcanite of the tasimeter by the adjusting nut. When thus brought to zero the copper wire of the shunt rheostat was taken off of one pin, thus increasing the resistance of the shunt perhaps to one-fiftieth of an ohm. The spot of light was generally deflected nearly off of the scale. The light was again brought to zero by varying the resistance of the tasimeter, and another one-half inch of wire included in the shunt, another deflection and another balance was obtained by the tasimeter. Thus by gradually increasing the delicacy of the galvanometer by increasing the resistance of the shunt and balancing at every increase, the whole of the current was allowed to pass through the galvanometer and the shunt taken off. When this point was reached the damping magnet or director was in close proximity to the case of the galvanometer. To increase its delicacy to the fullest extent it became necessary to raise the director to the top of the rod. This was done by raising it cautiously a quarter of an inch at a time, bringing the spot of light to zero each time by the tasimeter.

In order to form some idea of the delicacy of the apparatus when thus adjusted, a preliminary experiment was made on the evening of the 27th, with the star Arcturus. The tasimeter being attached to the telescope, the image of the star was brought on the vulcanized rubber. The spot of light from the galvanometer moved to the side of heat. After some minor adjustments, five uniform and successive deflections were obtained with the instrument, as the light of the star was allowed to fall on the vulcanite to produce the deflection, or was screened off to allow of a return to zero.

It was in this condition when the eclipse occurred. The tasimeter was placed in a double tin case, with water at the temperature of the air between each case. This case was secured to a Dollond telescope of four inches aperture. No eye-piece was used. At the moment of totality the spot of light was slowly passing towards cold. When I withdrew a tin screen and allowed the edge of the luminous corona to fall upon the rubber, the spot of light stopped, went gradually off of the scale towards heat, its velocity accelerating as it approached the end.

The time required for the light to leave the scale was from four to five seconds.

I interposed the screen and endeavored to bring the light back to zero, but I was unsuccessful. Had I known that the heat was so great I should have used a platinum strip in place of the vulcanite, and decreased the delicacy of the galvanometer by the approach of the damping magnet. I then should doubtless have succeeded in getting two or more readings, and afterwards by comparison with bodies of known temperature should have obtained a near approach to the temperature of the sun's corona.

Respectfully yours, THOMAS A. EDISON.

Menlo Park, N. J., August 15, 1878.

ART. VI.—*Description of a Paper Dome for an Astronomical Observatory;* by Professor DASCOM GREENE, Troy, N. Y.

AN astronomical observatory has recently been erected for the Rensselaer Polytechnic Institute, through the liberality of Mr. E. Proudfit of this city. In maturing the plans, and supervising the erection of the building, I have introduced an improved method of constructing revolving domes, a brief account of which may not be without interest.

While making the preliminary inquiries, I ascertained that a dome of the dimensions required, constructed in any of the methods in common use, would weigh from five to ten tons, and require the aid of cumbersome machinery to revolve it. It therefore occurred to me to obviate this objection by making the frame-work of wood, of the greatest lightness consistent with the requisite strength, and covering it with paper of a quality similar to that used in the manufacture of paper boats; the principal advantages in the use of these materials being that they admit of great perfection of form and finish, and give extreme lightness, strength, and stiffness in the structure,—prime qualities in a movable dome. A contract was accordingly made with Messrs. E. Waters & Sons, of this city, the well-known builders of paper boats, for the construction of the dome, and they have carried out the undertaking with great skill and success.

The dome is a hemisphere with an outside diameter of twenty-nine feet. The frame-work consists primarily of a circular sill which forms the base, and two semi-circular arch girders set parallel to each other, four feet apart in the clear, and spanning the entire dome. These are firmly attached to the sill and kept in a vertical position by means of knee-braces. The sill and girders are of seasoned pine, the former being 8¼ inches wide by 3½ thick, and the latter each 4½ by 3 inches.

The paper covering of the dome is made in sixteen equal sections, such that when set up side by side, their bases on the sill, and their extremities meeting at the top, they form a complete hemispherical surface. The frame-work of each section consists of three vertical ribs of pine each 3¾ inches in width and ¾ of an inch thick, one at each side and one midway between, and meeting at the apex. The paper was stretched over this frame-work as follows:

A wooden model of full size being made of that portion of the dome included within one of the sections, with a surface truly spherical, the frame-work of a section was placed in its proper position on the model, so that its outer edges formed part of the same spherical surface, and covered with shellac where it was to be in contact with the paper. The sheet of paper cut in the proper form was then laid on the model while moist, the edges turned down over the side ribs, and the whole placed in a hot chamber and left until thoroughly dry. In this way the several sections were dried off in succession over the same model. The paper used is of a very superior quality, manufactured expressly for the purpose by Messrs. Crane Brothers, of Westfield, Mass. Its thickness after drying is about one-sixth of an inch, and it has a structure as compact as that of the hardest wood, which it greatly excels in strength, toughness and freedom from any liability to fracture.

After being thoroughly painted, the several sections were ready to be set up side by side on the sill and connected together by bolting through the adjacent ribs. The space between the arch girders being left uncovered on one side from the sill to a distance of two feet beyond the zenith, the upper ends of the sections required to be cut off and accurately fitted to the girders. The joints between sections were made weather proof by inserting a double thickness of heavy cotton cloth saturated with white lead paint. The adjacent side ribs were then bolted firmly together through the paper and cloth, the lower ends attached to the sill by angle irons, the upper ends bolted to the girders, and the lower edge of the paper turned under the sill and securely nailed. The joints were afterwards painted over on the outside. As the entire surface exposed is free from nail holes or other abrasions in the paper, the structure promises with an occasional coat of paint to last for many years, and to form an effective and serviceable roof.

The 4-feet opening between the arch girders is covered by a shutter which is also of paper stretched over a wooden frame. With the exception of about two feet at the lower extremity, this shutter is in a single piece. Attached to its sides are a series of iron rollers which run on a railway track of band iron laid down on the girders, by which means the shutter can be moved over to the opposite side of the dome. The wooden sides of the shutter have iron flanges attached to their lower edges, which project under the railway tracks, making the whole weather proof. The shutter is opened and closed by means of a windlass and wire rope.

The weight of the dome and its appurtenances is about 4,000 pounds. It is supported on six 8-inch balls which roll between grooved iron tracks, and can be easily revolved by a moderate pressure applied directly, without the aid of machinery.

ART. VII.—*On the Age of the Clay-slates and Grits of Poughkeepsie;*[*] by T. NELSON DALE, Jr.

IN Mather's geological sections of the Hudson River valley[†] the alternating argillaceous schists, slates and grits, on both sides of the river, in the vicinity of Poughkeepsie are assigned to the Hudson River Group. This term was originally intended to include the series between the Utica Slate below and the Medina Sandstone above. These rocks would thus represent the uppermost North American Lower Silurian.

In the geological map drawn by Logan and Hall, and appended to the Report of the Canadian Geological Survey, the rocks for some miles on both sides of the Hudson River, south of Rondout on the west side and of Rhinebeck on the east side, and extending southward beyond Poughkeepsie, are designated as Calciferous and Quebec. They are thus referred to the middle division of the North American Lower Silurian.

Dana, referring to this subject, observes in his Manual of Geology, ed. 1874, on page 184: "The extension of the Quebec group southward, along the west side of the Green Mountain range, covers, according to Logan, a considerable part of New York east of the Hudson, the rock being part of the non-fossiliferous clay-slate (formerly called Hudson River slate) which outcrops near Poughkeepsie, etc. The area is divided on the west from that of the true fossiliferous Hudson River beds (or Cincinnati series, as now called), by a great fault, which, beginning near Quebec, crosses the Hudson near Rhinebeck, fifteen miles north of Poughkeepsie. As these rocks have afforded no fossils, the age is still doubtful." Again on page 196 of the same work, he says, under the head of Cincinnati Epoch: "In New York, the Hudson River beds include shales and sandstones. They are the Lorraine shales of Jefferson County (the Pulaski shales of the New York Annual Reports), containing some thin beds of limestone. The slates along the Hudson River, to which the name was especially applied, have been proved to be in part Primordial, and part, probably of the Quebec series."

These rocks have therefore been first assigned to the Trenton Period, then to the Canadian Period and afterwards declared unfossiliferous, and thus a question has been raised as to their real age.

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[*] A paper containing the substance of this article, in a different form, and entitled "A contribution to the Paleontology of the vicinity of Poughkeepsie," was read by the author before the Poughkeepsie Society of Natural Science on December 4th, 1878, and is being published in the Proceedings of that Society.

[†] Nat. Hist. of N. Y., Part IV, Geology, by William W. Mather; Plates 16, 18, 34, 46

In the spring of 1878, I discovered in a ledge of argillaceous schist, back of the observatory of Vassar College, and a few rods beyond the college fence, some fossil Brachiopoda. Shortly afterward I found others, together with Crinoid stems, at the first ledge of glaciated rock on the Stormville road, between Casper Creek and the first limestone ridge. Again in November and December of the same year, in ascending the first range of high hills which rises about a mile west of the Hudson* opposite Poughkeepsie, I came across a large outcrop of argillaceous schist, containing an abundance of Brachiopoda and Crinoid stems. After it had become known that fossils were to be found in the vicinity of Vassar College, several of the students found some, and Mr. H. Booth of Poughkeepsie, collected a number of Brachiopoda and Crinoid stems at the ledge back of the observatory. On another visit to the locality on the base of Marlborough Mountain, I found a univalve shell and Fucoids.

I am indebted to Mr. James Hall, the State Paleontologist, for the identification of the fossils from these localities. They are: *Orthis testudinaria* Dalm.; *Orthis pectinella* Con.; *Leptæna sericea* Sow.; *Strophomena alternata* Con.; *Buthotrephis subnodosa* Hall.

The cast of the univalve hardly admits of perfect determination, but it strongly resembles that of *Bellerophon bilobatus.* The Crinoid stems measure from one to three millimeters in diameter. There are from thirty-five to forty grooves on the ends, radiating from the central tube to the circumference. The surface is round and smooth. Casts of the central tube, and of the spaces between the joints are preserved, and might easily be mistaken for stems with annular corrugations on the exterior.

In some parts of the rock, Crinoids are very abundant, in others *Orthis testudinaria* forms a conglomerate. *Leptæna sericea*, *Orthis testudinaria* and the Crinoid stems are characteristic of both the Vassar College locality and of that on the west of the Hudson. The Brachiopoda are represented by internal casts, impressions of both exterior and interior, and by the shell itself in a greatly altered state. Sometimes the calcareous shell is preserved with but little alteration. The more minute striæ of *Leptæna sericea* can be counted in some specimens. Nearly all the fossils are more or less distorted. The general character of the rock is the same on both sides of the river. There are irregular alternations of grit, clay slate and shale, in some places,

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*** I take this hill to be a continuation of what Mather calls Marlborough Mountains.**

with thin strata of limestone. The grit is sometimes slightly calcareous.

The geological significance of these fossils is evident. I quote, however, from Hall:[*] "*Orthis testudinaria:* This species rarely, or never, appears in the Utica slate, but reappears near the middle of the Hudson River shales, and continues nearly to their termination, being abundant at Turin, Lorraine, Pulaski, and other places. It is more rarely found in the vicinity of the Hudson River and in the Mohawk valley." p. 288. "*Orthis pectinella:* This species, though not usually abundant, occurs nevertheless in nearly every part of the Trenton limestone, though unknown to me in the Hudson River group." p. 123. "*Leptæna sericea:* The thin layers in the lower part of the Trenton limestone are often entirely covered with the perfect shells or separated valves of this species. It occurs in all localities of the Trenton limestone. It also reappears in the Hudson River group, being in some localities very abundant." p. 110. "*Strophomena alternata:* This is one of the species, which, commencing its existence prior to or at the epoch of Trenton limestone, continues in great numbers throughout the rock, and, though not appearing in the Utica slate, reappears in the Hudson River group in immense numbers, several thin strata in the upper part of this group being composed almost entirely of the shells of this species." p. 105. The occurrence of these fossils in these localities would then establish the fact that the clay-slates and shales in the vicinity of Poughkeepsie, on both sides of the river, are fossiliferous and that they very probably belong to the Hudson River group, as indicated by Mather in 1843, certainly to some member of the Trenton Period. These facts also speak in favor of the retention of the term Hudson River group as advocated by Hall.[†]

Poughkeepsie, N. Y., Dec. 12, 1878.

Supplementary Note.—A visit to Marlborough on the west bank of the Hudson River, about eight miles south of Poughkeepsie, has just yielded the following results. In an outcrop of argillaceous schist near the river: *Orthis testudinaria*, *Orthis pectinella*, *Leptæna sericea* and Crinoid stems In a slightly calcareous grit at the southern extremity of Marlborough Mountain, there called Break-neck Hill, about three miles west of the river at this point: *Orthis testudinaria.*

Poughkeepsie, N. Y., Dec. 16, 1878.

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[*] Nat. Hist. of N. Y. Paleontology, vol. i.

[†] See Note upon the History and Value of the term Hudson River group in American Geological Nomenclature, by JAMES HALL, of Albany, N. Y., in Proceedings of the Amer. Assoc. Adv. Sci., 1877. This Journal, vol. xvi, p. 482.

ART. VIII.—*On the Electrolytic Estimation of Cadmium;* by EDGAR F. SMITH, Ph.D.

IN a recent article published in this Journal (vol. xvi, Sept., 1878), Professor F. W. Clarke calls attention to the estimation of cadmium by electrolysis, which, however, proved unsuccessful—the cadmium being indeed thrown out of the solution, but in such a form as to enclose impurities; yielding consequently unsatisfactory results.

Out of curiosity to see what might be effected by substituting some other salt for the chloride, I employed an acetate solution and met with success, as the following experiments show:

I. ·1450 grams cadmium oxide were dissolved in acetic acid, the excess of the latter evaporated upon a water bath and then the platinum crucible about half filled with water and placed upon a copper ring connected with the negative pole of a two-cell Bunsen battery, while joined to the wire leading from the positive pole was a strip of platinum foil extending into the acetate solution. The deposition of the cadmium upon the platinum crucible was regular and in a perfectly crystalline grayish white layer. In about three hours the separation was complete. The cadmium was first washed with distilled water, then with alcohol, and finally with ether. It was dried over sulphuric acid. The metallic cadmium weighed ·1270 grams, corresponding to 87·58 per cent Cd. The calculated percentage of metal in the oxide is 87·50.

II. ·2046 grams cadmium oxide placed in a small, rather broad platinum crucible, were dissolved in acetic acid, and after expelling the excess of the latter, water was added—the solution, however, remaining rather concentrated. The platinum vessel was connected with the negative pole of a bichromate battery. To the copper wire of the positive pole was attached a platinum wire from which was suspended a small platinum crucible, which dipped into the solution in the larger vessel. The space between the walls of the two crucibles was not more than an eighth of an inch; only two cells of the battery were employed. The deposit of the cadmium here as in the first experiment was perfectly crystalline and metallic in appearance. Not the slightest trace of spongy metal was visible. The separation was finished in about the same time as in (I). The metal was washed and dried as above. Found ·1790 grams metal, corresponding to 87·48 per cent Cd.

From various experiments made by me I find that good results may be obtained constantly by observing the following: 1st. Work with rather concentrated solutions of the acetate. 2d. Employ a sufficient number of cells of either battery, to give a rapid and rather energetic current.

Laboratory of the University of Pennsylvania, October 31, 1878.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the New Element, Philippium.*—Delafontaine has announced the discovery of a new element, in the earths obtained from the mineral samarskite, to which he has given the name *philippium*, after Philippe Plantamour of Geneva. The oxide of the new metal, philippia, having the symbol PpO, is yellow and has a color and a molecular weight intermediate between yttria and terbia. Admitting it to be a protoxide, the atomic weight of the metal would be between 90 and 95. Philippium formate crystallizes easily in small brilliant rhomboidal prisms less soluble than yttrium formate. The oxalate is more soluble in nitric acid than the terbium salt, less so than that of yttrium. The nitrate becomes dark yellow on heating it to fusion, the terbium and yttrium salts remain colorless. Concentrated solutions of philippium show a spectrum containing a magnificent absorption band in the blue-indigo (λ=4500 about) intense, broad, and well defined, which is characteristic of it, not being found in the spectra of terbium, yttrium or erbium. Two other narrower bands appear in the green, the more refrangible of which appears to belong to erbium, the less to philippium. Observing the spectrum of terbium solutions with sunlight and through blue glass, a weak band was observed in the violet (λ=4000 to 4050 about) only half as broad as the philippium band. The author questions whether it really belongs to terbium as Soret supposes, or to a new element, between terbium and erbium.—*C. R.*, lxxxvii, 559, Oct., 1878. G. F. B.

2. *On the New Element, Decipium.*—Delafontaine has reported the discovery of a second new element in the mineral samarskite from North Carolina, to which he gives the name *decipium*, from decipiens, deceiving. The oxide, if the formula DpO be assigned to it, has a molecular weight of 122; it has not been obtained sufficiently free from didymium oxide to enable the author to say that it is white, though its salts are colorless, the acetate crystallizes easily, being less soluble than that of didymium but more so than that of terbium. Potassio-decipium sulphate is but slightly soluble in a saturated solution of potassium sulphate, though it dissolves easily in water. The nitrate gives an absorption spectrum consisting of at least three bands, in the blue and the indigo. The most refrangible of these is a little less broad than that of philippium, is dark, and corresponds in its center to a wave length near 4160, being about half way between G and H. Neither didymium nor terbium gives bands in this region. The second band is narrow, intense, not defined on its edges, and is in the less refrangible part of the blue, corresponding to a wave length of 4780; nearly in the same place as one of the didymium bands, but far more intense. Finally a little to the right and

nearly to the limit of the blue and green is an appearance of the third. The earths of samarskite as now known are given by the author in the following tabular form:

Name.	Color.	Molec. weight.		Wave length of Charac. band.
Yttria	White	YO =74·5	(Delafontaine)	None.
Erbia	Rose	ErO =130	(Bunsen-Clève)	520–522
Terbia	Orange	TbO =114–115	(Delafontaine-Marignac)	400 about.
Philippia	Yellow	PpO =90 about	(Delafontaine)	449 about.
Decipia	White ?	DpO =122 about	(Delafontaine)	416
Thoria	White	ThO_2=267·5	(Delafontaine)	None.
Didymia	Brownish	DiO =112–114	(Marignac-Clève)	572–577
Ceria	Pale yellow			

He also calls attention to the numerical relations between the atomic weights, thus: Yttrium $=58$; Philippium $=74$ or $58+2\times8$; Terbium 98 or $58+5\times8$; Decipium 106 ? or $58+6\times8$; and Erbium$=$114 or $58+7\times8$.—*C. R.*, lxxxvii, 633, Oct., 1878.

G. F. B

3. *On the New Element, Mosandrum.*[*]—At a recent meeting of the French Academy (November 25th, 1878), a note by Dr. J. Lawrence Smith was presented, in which he claimed for himself priority in having been the first to call attention to the absence of cerium oxide, and to the new characters of certain earths, in the North Carolina samarskite, and to have described one of these under the name Mosandrum.

4. *On the New Element, Ytterbium.*—MARIGNAC has described some of the compounds of a new element, found in the Ytterby mineral gadolinite; it is associated with yttrium and erbium, and hence called by him *ytterbium.* In separating the earths of this mineral, he heated the mixed nitrates until they became pasty. On treating the mass with boiling water, an insoluble residue remained, in which the erbium was concentrated. By repeating the operation many times, a pure rose colored earth was obtained, which was erbia, the atomic weight rising to that of erbium, 128 or 129. On continuing the operation, he was surprised to find that the increase of the rose color, of the absorption bands and of the atomic weight which at first kept together, finally separated; the atomic weight slowly increasing, while the rose color and the bands diminished; so that the last product was perfectly white, its salts were colorless and its spectrum showed no absorption bands. The purest product gave an atomic weight of 130·8; hence 131 may be provisionally adopted. Ytterbium nitrate is decomposed by heat without coloration, the oxide is much less attackable by acids than the other oxides of this group, the sulphate is isomorphous with those of yttrium and erbium, redissolves easily and completely in a saturated solution of potassium sulphate, no precipitate being formed on boiling, the chloride in neutral solution is not precipitated by boiling with sodium hyposulphite, the formate dissolves in less than its weight of water and resembles the same salt of yttrium and erbium, and loses its crystal water at 100°. These properties distinguish it from thorium, the only element of this kind known

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[*] This Journal, xvi, 384, November, 1878.

whose atomic weight is high. Its symbol is Yb.—*C. R.*, lxxxvii, 578, Oct., 1878. G. F. B.

5. *On a Simple Vapor density Method.*—Victor Meyer has proposed a very simple mode of approximate vapor density determination, dependent on the measurement of the air expelled by the vapor. He uses an elongated cylinder of about 100 c. c. capacity, closed at bottom and having a tube of some length attached at top, in the side of which is a lateral tube by which the air may be conducted to a graduated tube. The vertical tube is to be closed with a cork. To use it, the apparatus is placed in the vapor of a liquid of sufficiently high boiling point, or even in a metallic bath. After the temperature has become constant and the air in the cylinder has finished expanding, the end of the lateral delivery tube is placed beneath a graduated tube full of water, the cork is removed, the substance dropped through the tube into the cylinder, and the vessel closed. The substance volatilizes at once and expels its own volume of air from the vessel, which is collected and measured in the graduated tube. Neither the capacity of the vessel nor the temperature of the bath are needed in the calculation. This requires only the weight of the substance, the temperature of the room, the height of the barometer and the volume of air expelled. The results are close enough for molecular weight determinations, as the figures given show.—*Ber. Berl. Chem. Ges.*, xi, 1867, Nov., 1878. G. F. B.

6. *On the Separation of Zinc from Nickel.*—Beilstein has proposed the use of citric acid in the analytical separation of nickel from zinc, having found that in presence of citric acid and citrates, zinc is completely precipitated by hydrogen sulphide, while all the nickel remains in the solution. The solution containing the two metals, which must be quite dilute and contain them as nitrates or sulphates, is treated with ammonia to alkaline reaction and is then acidulated with pure citric acid. Into the perfectly cold solution, hydrogen sulphide is passed for five or ten minutes, or until it strongly smells of the gas, allowed to stand for an half hour, repeating the operation until the odor no longer disappears on standing. The precipitated zinc sulphide is allowed to stand twenty-four hours in the cold, is filtered off and weighed. The filtrate is evaporated to a small bulk and from it the nickel is precipitated electrolytically. The separation is complete as is shown by the examples given.—*Ber. Berl. Chem. Ges.*, xi, 1715, Oct., 1878. G. F. B.

7. *On the formation of Purpureo-chromium salts.*—Jörgensen has succeeded, by the oxidation of an ammoniacal solution of chromous chloride $CrCl_2$, in producing a chloride of chloro-purpureochromium, the original sky-blue fluid becoming of a beautiful red color. The formula of the chloride of the new compound is $Cl_2[Cr_2(NH_3)_{10}]Cl_4$, analogous to purpureocobalt chloride, which it resembles in solubility. From aqueous solutions it is completely precipitated by hydrochloric acid. Nitric acid produces

in the aqueous solution a magnificent carmine red chloro-nitrate of the composition $Cl_2[Cr_2(NH_3)_{10}]\ (NO_3)_4$. In the solutions of this salt the chlorine is not precipitable by silver nitrate. Fluosilicic acid precipitates a silico-fluoride of chloropurpureochromium, which under the microscope appears isomorphous with the corresponding cobalt salt. The author has evidence of the existence of roseo and luteo-chromium.—*J. pr. Ch.*, II, xviii, 248, Nov., 1878.

G. F. B.

8. *On the Atomic weight of Iridium.*—SEUBERT has re-determined with great care the atomic weight of iridium, by igniting in a current of hydrogen, ammonio-iridium chloride and potassio-iridium chloride. The former gave as a mean 193·377; the latter 193·094; the mean of both being 193·220, H being 0·9975; or taking H as 1, the atomic weight of iridium is 192·744.—*Ber. Berl. Chem. Ges.*, xi, 1767, Oct., 1878. G. F. B.

9. *Preliminary Note upon the nature of the Chemical Elements.*—Mr. NORMAN LOCKYER has addressed the following note to the French Academy of Sciences:—"Reasoning from analogies furnished by the behavior of known compounds, I have proved that, independently of calcium, many bodies hitherto considered as elements, are also compound." Mr. Lockyer promises to forward to the Academy the necessary proofs of his assertion."—*Comp. Rend.*, No. 19, p. 673, Nov., 1878. J. T.

10. *Phenomena of Binaural Audition.*—Professor THOMSON, of University College, Bristol, England, thus sums up the results of his investigation upon this subject. "(*a.*) There is an interference in the perception of sound; for two simple tones capable of interfering are still heard to interfere when conducted separately to the two ears. (*b.*) When two simple tones in unison reach the ears in opposite phases, the sensation of the sound is localized at the back of the head. (*c.*) The localization of this acoustic "image" is independent of the pitch of the sound. (*d.*) If the difference of phase is partial, the sensation is localized partly in the ears and partly at the back of the head. (*e.*) If the difference of phase be complete but the intensities unequal, the acoustic "image" instead of being at the middle of the back of the head, is nearer that ear in which the sound is louder. (*f.*) It is possible to discern the difference between two compound tones which differ only in the phase but not in the pitch or intensity of their component partial tones. For when two such compound tones are separately brought to the ears so that the vibrations of any partial tone present reach the ears in opposite phases, that particular partial tone is singled out and localized at the back of the head. (*g.*) When two simple tones are led simply to the ears no differential tone is heard; there is some evidence that summational tones are heard. (*h.*) To binaural audition dissonances are excessively disagreeable and ordinary consonances harsh. (*i.*) Vibrations mechanically conveyed to a point of the parietal or occipital region of the skull at one side, are apparently heard in the ear of the other side of the head."

In his investigation the author made use of a telephone, which is thus seen to occupy a place in acoustic researches.—*Phil. Mag.*, Nov., 1878, p. 383. J. T.

11. *On the Economy and Subdivision of the Electric Light.*—Professor **Farmer** of the Torpedo Station at Newport, has written a letter to the Salem Observer, calling attention to the fact that the parlor of his house, No. 11 Pearl St., was lighted every evening during the month of July, 1859, by the electric light, and that this electric light was subdivided, too. Since this was nineteen years ago, it was, he thinks, undoubtedly the first private dwelling house ever lighted by electricity; a fact which may be a source of pride to the city of Salem some of these days. As we know of no one better qualified to give an opinion on these important questions, we give the latter portion of Professor Farmer's letter:

"A galvanic battery of some three dozen six-gallon jars was placed in the cellar of the house, and it furnished the electric current which was conveyed by suitable conducting wires to the mantle-piece of the parlor, where were located two electric lamps, on each end of the mantle-piece—(I should not wonder if the screw holes were there at this day). Either lamp could be lighted at pleasure, or both at once, by simply turning a little button to the right for a light, to the left for a dark. No matches, no danger, no care to the household, nor to anyone except to the man who attended to the battery.

This light was noticed as being soft, mild, agreeable to the eye, and more delightful to read or sew by than any light ever seen before. Its use was discontinued, at that time, for the simple reason that the acids and zinc consumed in the battery made the light cost about four times as much as an equivalent amount of gas-light. Now that we can have cheap electricity from the dynamo-electric machine, we may soon expect better things of it.

In the year 1875 I subdivided an electric current into forty-two different branches, putting a light into each branch. All these lamps were supplied with electricity from one machine, which did not weigh more than eight hundred pounds, and which was driven by a small steam engine.

Now a word as to the cost of electric light as compared with light from gas. Perhaps on the average, one pound of illuminating gas will, if burned in an hour in five different burners, give fifteen candle lights to each burner, or seventy-five candle lights in all. One pound of illuminating gas possesses a sufficient store of energy to enable it to give out by combustion, from eighteen thousand to twenty-one thousand units of heat, or the equivalent of from thirteen to sixteen million foot-pounds of work. This, if burned in an hour, would average from two hundred to two hundred and sixty thousand units of work per minute, or say from three thousand to thirty-five hundred foot-pounds per minute per candle light.

Now a very large electric light, say ten thousand candles, does not demand or consume more than fifteen or twenty foot-pounds of energy per minute per candle light, and even so small an electric light as twenty or thirty candles need not consume so much as two hundred foot pounds per minute per candle light. So it might not seem very extravagant to expect that one pound of gas per hour could be burned in a suitable furnace under a proper boiler, and steam be taken from this boiler to a steam engine, and this engine drive a magnetic electric machine which should supply electricity to five electric lamps that would shed forth more light than could be given by five of the best gas lamps known, each lamp consuming at the rate of one-fifth of a pound of the best illuminating gas per hour; and this would not be half so absurd an expectation as it would have been three years ago, for some visionary to have predicted that the talking Phonograph would succeed in embalming speech."

U. S. Naval Torpedo Station, Newport, R. I., Oct. 30, 1878.

II. Geology and Mineralogy.

1. *Report of the Geological Survey of the Fortieth Parallel*, Clarence King, Geologist in charge: Volume I, *Systematic Geology*, by Clarence King. 804 pp. 4to, with 28 plates and 12 analytical geological maps, and accompanied by a geological and topographical atlas. Submitted to the Chief of Engineers, and published by order of the Secretary of War, under authority of Congress.—The field work of the Geological Survey of the 40th Parallel commenced in 1867, and continued until 1873; the no less important labor of studying the material collected, arranging for publication facts observed, and drawing conclusions from them has only been finally concluded during the past year. The study of the geology of the region explored was carried on by Mr. King and his associates, Mr. Arnold Hague and Mr. S. F. Emmons, of the mining districts by Mr. J. D. Hague, and of the botany by Mr. S. Watson; the topography was in the hands of Mr. J. T. Gardner.

The area covered by their explorations forms a belt of country 100 miles wide, from north to south, and extending from the meridian 104° west in a direction a little south of west as far as longitude 120° west; it partly encloses the 40th Parallel, but near the eastern extremity deviates a little to the north of the line. Of this tract of country Mr. King says, in the opening chapter of his volume: "It has rarely fallen to the lot of one set of observers to become intimate with so wide a range of horizons and products. Embracing within its area a pretty full exposure of the earth's crust from nearly the greatest known depths up through a section of 125,000 feet, taking in all the broader divisions of geological time—a section which has been subjected to a great sequence of mechanical violence, and can hardly fail to become classic for its display of the products of eruption—this Exploration has actually covered an epitome of geological history." It should be added that, at the time when Mr. King's party took the field, the region was one which was unmapped, unstudied, and of which nothing but a few isolated details was known. The value of the work accomplished can be best appreciated when the difficulties which had to be overcome are understood.

The several volumes of the Survey, in their order of publication, are as follows:—Vol. iii, Mining Industry, by James D. Hague, with geological contributions by Clarence King, 1870. Vol. v, Botany, by Sereno Watson. Vol. vi, Microscopical Petrography, by Ferdinand Zirkel, 1876. Vol. ii, Descriptive Geology, by Arnold Hague and S. F. Emmons, 1877. Vol. iv, Part I, Palæontology, by F. B. Meek; Part II, Palæontology, by James Hall and R. P. Whitfield; Part III, Ornithology, by Robert Ridgway, 1877. Geological Atlas, containing ten double maps, 1878. Vol. i, Systematic Geology, by Clarence King, 1878.

The concluding volume in the series, now published, presents a systematic statement of the geological facts taken in order of geological time, collected by Mr. King and his associates, Messrs. Hague and Emmons, with the conclusions which he himself has drawn from them. The detailed presentation of these facts, in their geographical order, had already been given in volume ii, on Descriptive Geology (noticed in this Journal, vol. xvi, p. 234). In thus bringing together in a single volume the grand results of his Survey, Mr. King has given much greater and more permanent value to the labors of himself and his associates. The clear and systematic manner in which both the facts observed and the theories advanced are presented, is worthy of high praise; Mr. King's graceful pen never showed itself to better advantage. It is perhaps unnecessary to add that the appearance of the volume is all that could be desired; the many plates are executed in the best manner. An especially valuable feature of the volume is to be found in the series of geological charts, one of which accompanies the description of each formation and gives the distribution of the rocks belonging to it. In another number we expect to cite some pages from the work, which will show some of the more important conclusions reached.

2. *Tenth Annual Report of the United States Geological and Geographical Survey of the Territories.* Being a Report of Progress of the Exploration for the year 1876, by F. V. Hayden, U. S. Geologist; 546 pp. 8vo, with 74 plates and 3 large maps. Washington, 1878.—This large and valuable volume contains, besides the opening letter of the geologist in charge, the following reports: Part I, by C. A. White, On the geology of a portion of Northwestern Colorado; by F. M. Endlich, on the geology of the White River District, on the Mineralogy of Colorado, and on the Erupted rocks of Colorado; by A. C. Peale, on the geology of the Grand River District; by W. H Holmes, on the geology of the Sierra Abajo and West San Miguel Mountains; Part II, Topographical reports by A. D. Wilson, Henry Gannett, G. B. Chittenden and G. R. Bechler; Part III, On Archæology and Ethnology by W. M. Holmes, W. H. Jackson and W. J. Hoffman; and

Part IV, On Cretaceous and Tertiary plants by Leo Lesquereux; On injurious Insects by A. S. Packard, Jr. The Archæological reports contain detailed descriptions of the ancient ruins in Southwestern Colorado and adjacent territories. A large number of excellent plates, illustrating both the distribution and character of the cliff houses, and also the remains of pottery and other implements found in connection with them, besides admirable plans, sketches, sections, increase the value of the reports. The Report contains also two beautiful colored geological maps of Colorado, and a third map giving the drainage of the Territory.

3. *Bulletin of the United States Geological Survey of the Territories;* F. V. HAYDEN, Geologist-in-charge. Vol. iv, No. 4.—This number of the Bulletin contains papers by S. H. Scudder on the fossil Insects of the Green River shales; by D. S. Jordan on Fishes of Dakota and Montana, collected by Dr. Coues; by J. W. Chickering on Plants of Dakota and Montana, collected by Dr. Coues; by F. M. Endlich on Erosion in Colorado; by C. A. White on the Laramie Group; by J. A. Allen on the American Sciuri or arboreal squirrels. An index to volume iv closes the number.

4. *On the Origin of Stylolites;* by EDWARD T. NELSON. (Communicated.)—During the past summer while spending a few days at a Post of the Hudson's Bay Company, called Red Rock, situated three miles above the mouth of Nipegon River, Lake Superior, I had opportunity for observing the formation of stylolites on a grand scale. The left bank of the river, just below Nipegon Rapids, is, perhaps, fifty feet in height, and is composed of strata of fine sand, with thin intercalated layers of clay. Owing to the protecting influence of the clay the face of the bank presents a series of steps. For a distance of some hundreds of feet, and vertically from top to bottom, the surface, at the time of our visit, was covered with stylolitic columns. In each case these columns reached from one stratum of clay to the next below, and hence varied in height from two inches to as many feet. During the first afternoon it was raining gently. The water falling over the edges of the exposed layers of clay washed the *sand vertically from beneath.* In this way each stratum of sand presented the same projections and crevices as its covering layer of clay. As soon as the sun came out the exposed edges of the stylolites became covered by a very thin pellicle of the clay and were thus preserved. Wishing to learn whether these columns became sufficiently hard to stand pressure, I removed, very gently, portions of the talus of sand from the base of the hill and found within perfectly preserved columns. The inner face of the talus was, of course, the exact obverse of the stylolites.

Ohio Wesleyan University, Oct. 22d, 1878.

5. *Bowlders in Coal.*—During a recent geological excursion with the Senior class of Denison University, I found at New Straitsville, Perry County, Ohio, a bowlder of hard gritty sandstone, ten inches in diameter, in a seam of coal. It was covered to the depth of one foot and rested upon seven feet of coal, the

seam being the Nelsonville, or "Great Vein," which lies two to three hundred feet above the base of the Coal-measures. The roof is a bluish gray shale containing the usual Carboniferous fossils.

It seems improbable that this bowlder was brought into the ancient marsh when the material for the lower seven feet of coal had accumulated, and was then covered with the several feet of vegetable matter which are now compressed into the upper foot of coal. The Nelsonville seam has a wide distribution in south-eastern Ohio and Kentucky. It is the most reliable and persistent coal of the lower productive measures. This implies that the marsh in which it accumulated was very widespread, and that it long retained its character as an area of sluggishly moving, or stagnant waters, so choked with rank vegetation that drift-wood or floating ice (if any such thing existed in that age) would have no chance of being carried far over its surface. But it afterward sank beneath a shallow sea, muddy with the sediment which is now hardened into the roof shales. Sometimes during this submergence the bowlder was dropped upon the still soft and yielding mass of vegetation and sank into it to a considerable depth. By what agency it was transported from the shores of that ancient sea to its present resting place is uncertain. Two similar cases are on record, and two eminent Ohio geologists have speculated upon the causes of the phenomena. Professor E. B. Andrews (Report of Progress, 1870, p. 78) mentions a large quartzite bowlder in this same Nelsonville seam at Zaleski, Vinton County, and attributes its transportation to floating ice. Professor J. S. Newberry (Ohio Reports, vol. ii, p. 174) mentions one of talcose slate found by him in Coal No. 2, in Mahoning County, and opines that it was brought there by being "entangled in the roots of trees, and thus floated and dropped." Whatever may have been the buoyant material we can readily conceive that, once upborne upon the water, these bowlders might easily have been driven by winds, or carried by currents, to where we now find them, and penetrated the material of the coal by virtue of their weight and compactness, while the mud carried by the same waters spread over the coal a sheet of fine sediment without mingling with it.

Granville, Nov. 19th, 1878. L. E. HICKS.

6. *Ashburner on Oil-well Records in McKean and Elk Counties, Pennsylvania.*—In a citation from this memoir on page 393 of the preceding volume, the sentence reading "We are sure that the rocks maintain a constant thickness between these two points," should read "We are not sure," etc.

III. BOTANY AND ZOOLOGY.

1. *Flora Brasiliensis.*—The publication has made great progress during the year 1878. In February appeared fascicles 75 and 76; in June fasc. 77, in August fasc. 78. The subjects, in order of publication, are:

Hippocrateaceæ, by Dr. J. Peyritsch, Curator of the Vienna herbarium. While retaining the order, it is remarked that one isomerous genus makes a transition to *Celastraceæ.*

Meliaceæ, by Casimir DeCandolle, who has recently published a monograph of the whole order in the series which is to continue and supplement the Prodromus. This order is not very largely developed in Brazil.

Hederaceæ, by E. Marchal, Professor of Botany at Brussels. The Brazilian species belong to four genera, which are well illustrated.

Lemnaceæ, by Professor Hegelmaier of Tübingen, the monographer of the order. The three genera, *Wolffia*, *Lemna*, and *Spirodela* are well illustrated in a single plate, and the anatomy and morphology are fully expounded.

Araceæ, by Professor Engler, late of Munich, now translated to Kiel. There are about ninety Brazilian species out of 738 known to the monographer, who arranges them under ten sub-orders, and the larger sub-orders have two, three, and five tribes. But among the sub-orders are *Pistiaceæ* and *Lemnaceæ.* The whole is evidently worked out conscientiously, and is admirably illustrated by fifty-one plates, which abound in analyses. One of them is a photograph of magnified stem-sections.

Rafflesiaceæ, by Count Solms-Laubach, Professor at Strassburg. In Brazil are two known species of *Apodanthes* and four of *Pilostyles.* The single plate of illustrations is excellent.

Nymphæaceæ, by Professor Caspary of Kœnigsberg, are amply and well illustrated. Three folio plates are given to *Nymphæa ampla* and its varieties, six to other species, and two to *Cabomba* and some details of *Victoria.* Three typical species of *Cabomba* are described, and the character of *C. Caroliniana*, with full descriptive details is given in a foot-note. The *Nelumbium* of South America proves to be *N. luteum;* and the Japanese *N. nuciferum* is thought to be hardly different. Three species of *Victoria* are indicated, but with doubts as to their distinctness. One of the ten tropical American species of *Nymphæa*, viz: *N. ampla*, well marked by having the carpels separate through the center and cohering only dorsally, reaches Texas.

Cucurbitaceæ are elaborated, with much detail, by A. Cogniaux, a Belgian botanist. Introductions included, there are twenty-nine Brazilian genera, and one hundred and eleven species, arranged under the series proposed in Bentham and Hooker's Genera Plantarum. Eichler is followed in placing the order next to Campanulaceæ, a reversion to the ideas of Bernhard Jussieu and Adanson. *Cucurbita Pepo* is thought to be of Asiatic origin; perhaps rightly. But our Indians had it, along with *Nicotiana rustica*, which is certainly an old-world species. *Echinocystis* is still mixed up with *Megarrhiza*—a wholly distinct genus,—and with two Brazilian plants which, we venture to say, are not congeners of the true *Echinocystis.* The order is here illustrated by thirty-eight plates. A. G.

2. Heer: *Flora Fossilis Arctica.* Tome v. 1878.—This new volume, like most of its predecessors, is composed of separate

memoirs, some here first printed, some extra issues from academic transactions and the like. The first paper, on the Miocene Flora of Grinnell's Land (with nine plates and a map and sketch), is originally printed at Zurich. The two following papers, on Siberian and Eastern Asian fossil plants, are from the Memoirs of the Imperial Academy of St. Petersburg; the remaining two are from the Memoirs of the Royal Swedish Society at Stockholm, and illustrate the Miocene flora of Sachalin and the *Cordaites* of Nova Zembla. There are numerous figures. The first named paper most interests us, by the announcement of the discovery of the remains of a Miocene Spruce of the *Tsuga* group, i. e., allied to our Hemlock Spruce; also of the veritable Silver Fir of Europe! A. G.

3. *Epping Forest, and how best to deal with it*, is an article in the Fortnightly Review for November last, and separately issued, by ALFRED R. WALLACE. It urges—now that the ground which this ancient forest in the neighborhood of London covered, and in part still covers, is consecrated by act of Parliament for the recreation and enjoyment of the public forever—that the large waste portions shall be replanted in a way that may exemplify and reproduce, separately, the several kinds of forest of the northern hemisphere. Even some forests of the temperate portions of the southern hemisphere—of New Zealand, for instance, may be hopefully planted. The complete feasibility and the great interest of this project are well set forth, and are fortified by the authority of this Journal. Mr. Wallace, who is exceedingly well qualified to judge, adopts fully the theoretical views which are maintained in recent articles of this Journal, as to the cause of the poverty of Europe in indigenous trees, in comparison with North America and Eastern Asia, and her own Tertiary epoch; and would reclaim for England the trees and shrubs of which she was long ago deprived by icy fate. A. G.

4. *Die Algenflora des Weissen Meeres;* by Dr. CRISTOPH GOBI. (Extr. from Mem. Imp. Acad. Sciences, St. Petersburg, vol. xxvi, no. 1.).—The above named paper is the first detailed account of the algæ of the White Sea. The species are principally those found throughout the Arctic Ocean; but Dr. Gobi remarks that the vegetation of the southern part of the White Sea has a more northern character than that of the northern part; which is explained by the statement that many forms of Western Europe which make their way to the northern part do not extend to the southern part of the White Sea. Dr. Gobi unites a considerable number of species considered by Agardh and others to be distinct, even regarding *Rhodomela lycopodioides* as a form of *R. subfusca*, and *Polysiphonia arctica* as a variety of *P. variegata*. *Rhodophyllis veprecula* Ag. is referred to *R. dichotoma* Lepechin. The paper contains valuable references to the species of Ruprecht in the St. Petersburg Academy's herbarium. W. G. F.

5. *North American Fungi: Fungi Americani, Centuries I and II;* by H. W. RAVENEL and M. C. COOKE. *North Ameri-*

can Fungi; by J. B. ELLIS.—Since the *Fungi Caroliniani Exsiccati* by Ravenel, the last volume of which appeared in 1860, a large number of new species of fungi have been described by writers in Europe and this country, only a small number of which have ever been issued in any of the series of Exsiccati, which have in recent years become uncomfortably numerous. Several American species, to be sure, have been published in Thümen's Mycotheca Universalis, but, comparatively speaking, the number is small. From the nature of the plants themselves, and the fact that many mycologists remote from one another are constantly describing new species, many of which are founded on very minute distinctions, it is very much to be desired that an authentic series of American fungi should be in the hands of leading mycologists of Europe and this country. For this reason, if for no other, we welcome the fasciculi just issued by Messrs. Ravenel and Cooke, and that by Ellis.

The first series named includes specimens collected in Georgia and Florida by Mr. H. W. Ravenel, whose *Fungi Caroliniani* have made his name familiar to all students of fungi. The determination of the species and their arrangement has been undertaken by the well-known British mycologist, Mr. M. C. Cooke. The series will include about four hundred species, published in centuries, at the rate of twenty-one shillings each. American orders may be addressed to H. W. Ravenel, Aiken, S. C. The series includes a number of new species, which are being described in the current numbers of Grevillea.

The second of the series named is issued by Mr. J. B. Ellis, of Newfield, N. J.; and the first century contains species collected by him in the vicinity of Newfield, including a number of the new species described by Cooke and Ellis in Grevillea, and by Ellis and Von Thümen in the Torrey Bulletin. Mr. Ellis intends in the succeeding centuries of his work to include species from all parts of the United States, and has secured the aid of several mycologists in different parts of the country, who will furnish specimens and, at times, descriptions of species. So far as is practicable, an effort will be made to place in the same fasciculus only plants belonging to the same order, so that the student will find a large suite of related species placed near together for comparison. Century II will contain principally *Ascomycetes*, by Mr. Ellis, and Century III, *Uredinei*, by W. G. Farlow. The series will include common as well as rare forms, and it is to be hoped that it may become for this country what Rabenhorst's *Fungi Europæi* is for Europe. Each fasciculus is neatly bound in a form similar to that of Rabenhorst's Fungi, and is sold at the rate of $7.00. Orders can be sent to J. B. Ellis, Newfield, N. J.

W. G. F.

6. *The Early Types of Insects;* by SAMUEL H. SCUDDER. (Abstract of a paper read before the National Academy of Sciences, November 5, 1878).—The earliest remains of insects from the Paleozoic rocks were announced in 1835 by Audouin and

Corda. Since then many authors, especially Germar and Goldenberg, have added to our knowledge, until now perhaps one hundred species are known. Yet insect remains in the older strata may still be looked upon as the greatest rarities, and by far the larger part of them are known to us only by their wings.

It is of course of prime importance that we should understand the relative subordination of the larger groups in insects before investigating their order of succession in time; for one of the principal difficulties in attempting to harmonize their structural and geological relations has been in the erroneous views which have been maintained of the relative rank of the suborders of Hexapods and of their division into series. The author contended for the accuracy of Packard's classification, which separated them into Metabola and Heterometabola, the former including the Hymenoptera, Lepidoptera and Diptera; the latter the Coleoptera, Hemiptera, Orthoptera and Neuroptera, the arrangement being in a descending order. He was also inclined to agree with Dohrn in his estimate of the ordinal value of the peculiar combination of characteristics in Eugereon and other early insects and to accept, but with somewhat different limits, the term Palæodictyoptera applied to this group by Goldenberg. He discussed the times of appearance and relative abundance of the different suborders of Hexapods and concluded with the following recapitulation:

(1.) With the exception of the few wings of Hexapods known from the Devonian, the three orders of insects—Hexapods, Arachnids and Myriapods—appeared simultaneously in Carboniferous strata. (2.) All Carboniferous and Devonian insects are Heterometabola, the Metabola making their first appearance in Jurassic strata. (3.) Many synthetic or comprehensive types existed in Paleozoic times, combining the characters either of all the Heterometabola; of Orthoptera and Neuroptera; or of Neuroptera proper and Pseudoneuroptera. (4.) The Devonian insects either belong to comprehensive types related to the two lower suborders only, or are low Pseudoneuroptera; and were undoubtedly aquatic in early life. (5.) The lower suborders of Heterometabola (Orthoptera and Neuroptera) were much more abundant in Paleozoic times than the higher (Coleoptera and Hemiptera). (6.) Nearly all the Paleozoic Orthoptera belonged to the lower, nonsaltatorial families, and are almost exclusively cockroaches. (7.) The Neuroptera proper were at that time much rarer than the lower Pseudoneuroptera. (8.) All the earlier types were therefore of inferior organization. (9.) The general type of wing structure in insects has remained unaltered from the earliest time. (10.) With the exception of two species of Coleoptera, the front and hind wings of Paleozoic insects were similar and membranous. (11.) The series of facts presented to us by the progress of geological research leads to the conviction of the probable existence and possible discovery, in the Devonian and even in the Silurian formation, of winged insects, still more generalized in structure than any yet detected in the Paleozoic rocks.

It may further be added that nearly all the earlier insects were large, many of them gigantic in size; and further, that there is a striking similarity between the Carboniferous insect fauna of Europe and North America.

IV. ASTRONOMY.

1. *Constants of the Terrestrial Spheroid.*—In the Astron. Nach., No. 2,228, Professor LISTING gives the following results of his determination of the constants of the earth's figure:

$$\begin{array}{llll} a & = 6{,}377{,}377^{\mathrm{m.}} & l_0 & = 990{\cdot}9948^{\mathrm{mm.}} \\ b & = 6{,}355{,}270^{\mathrm{m.}} & l^* & = 993{\cdot}5721^{\mathrm{mm.}} \\ R & = 6{,}377{,}000^{\mathrm{m.}} & l' & = 996{\cdot}1495^{\mathrm{mm.}} \\ Q_0 & = 10{,}017.560^{\mathrm{m.}} & g_0 & = 9{\cdot}780728^{\mathrm{m.}} \\ Q & = 10{,}000{,}205^{\mathrm{m.}} & g^* & = 9{\cdot}806165^{\mathrm{m.}} \\ w & = 288{\cdot}4800 & g' & = 9{\cdot}831603^{\mathrm{m.}} \end{array}$$

Also in general, $l = 990{\cdot}9948 + 5{\cdot}1547 \sin^2\varphi$,

$$g = 9{\cdot}780728 + 0{\cdot}050875 \sin^2\varphi.$$

In these expressions $a =$ equatorial rad., $b =$ polar rad., $R = (a^2b)^{\frac{1}{3}}$, or mean radius, $Q_0 =$ equatorial quadrant, $Q =$ meridian quadrant; $w = a \div (a - b)$, or eccentricity of merid. section; l_0, l^* and l' are the lengths of the second's pendulum at the equator, 45°, and pole; g_0, g^* and g', the force of gravity at the equator, 45° and pole; and l and g the corresponding values at any latitude φ. H. A. N.

2. *Failure of Meteors from Biela's Comet in* 1878.—Mr. E. T. SAWYER writes from Cambridge as follows, under date of December 9th:—As far as my observations show, the expected shower of Biela's, proved a complete failure. I carefully looked for meteors conformable to a radiant near γ Andromedæ on the following dates: –November 23, 24, 26, 29, 30, and December 6, 7, and 8. The watches each evening varied from one to four hours in duration, and aggregate about seventeen hours in all. Cloudy weather interfered with watching for a week previous to the 23d, with the exception of a few minutes on the 21st, also on the 25th, 27th, 28th, and December 1st, 2d, 3d, 4th, and 5th. Strong moonlight also prevented the recording of faint meteors after November 29th. During the seventeen hours or more of watching, only three meteors were mapped radiating with any certainty from the deduced center near γ, and these paths prolonged backward meet exactly at R. A. 25° and 42°. Of the three recorded, two were seen during the four hours' watch on the 26th. H. A. N.

3. *Abriss der Praktischen Astronomie*, von Dr. A. SAWITSCH, translated into German from the 2d Russian edition, by Dr. C. F. W. Peters, assistant in the Observatory at Kiel. 848 pp. 8vo, Wilhelm Mauke, Leipzig, 1879.—The first edition of this work, translated from the Russian by Dr. Götze in 1850, has been for near thirty years a standard work for the subjects embraced in it. It is devoted principally to the instruments and processes

employed in the determination of latitudes and longitudes. It does not describe the fixed instruments of the observatory, and is therefore more complete in respect to portable ones.

The present edition has been quite fully revised, the changes in instruments and improvements of methods having required considerable changes in the matter. The Repsold vertical circle and the Ertel universal instrument are especially described. The more recent methods of utilizing solar eclipses for determination of longitude replace the older ones. H. A. N.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *International Geological Congress.*—The American Association for the Advancement of Science, at its meeting in Buffalo, August, 1876, appointed an international Committee charged with the organization of an International Geological Congress, to be held in Paris during the Exhibition of 1878. This committee, which consisted of James Hall, W. B. Rogers, J. S. Newberry, J. W. Dawson, T. Sterry Hunt, R. Pumpelly and C. H. Hitchcock, with the addition of T. H. Huxley, Otto Torell, and E. H. Von Baumhauer, then present at Buffalo, chose James Hall for its chairman and T. Sterry Hunt for its secretary. A circular in various languages was at once issued, urging the importance of the proposed congress, for the consideration of which various points were suggested, and recommending the bringing together at the exhibition of collections illustrating the geology of all countries. The assurances of coöperation received by the secretary were such that after a few months, the Geological Society of France took up the matter in connection with the international committee, and naming a local committee, of which Hébert was president and Jannettaz, secretary-general, issued July, 1877, a circular embodying the suggestions of the first committee. This was followed by a second circular, dated February, 1878, fixing the opening of the Congress for the 29th of August. The local committee also prepared a catalogue of all the materials of geological interest in the Exhibition, as well as of all the public and private collections of Paris, which were thrown open to the members of the Congress.

The Congress was opened on the day appointed in the palace of the Trocadero, the Minister of Public Instruction for France, presiding on the occasion, and six daily sessions were held, with Hébert for president, assisted by numerous vice-presidents selected from the various nationalities. The whole number of members enrolled was 328, of which about 250 were present. American geology was represented by James Hall, G. H. Cooke, J. P. Lesley, T. Sterry Hunt, W. P. Blake, E. D. Cope, and T. C. Chamberlin, and by Selwyn from Canada.

The first session was devoted to structural and dynamical geology and included among others, papers by Daubrée and Alphonse Favre, both giving results of experiments relative to the origin of fractures and foldings of the earth's crust. These were followed by Lory on the structure of the Alps, by de Chancourtois on the coördination of the lines and veins, and by De Lapparent on the foldings of the Chalk as disclosed by the examinations for the tunnel beneath the streets of Dover.

In the second session, James Hall discussed the history of the rise and progress of the nomenclature of the Paleozoic rocks in North America, and of the various geological maps, while Renevier, de Chancourtois and Huguenin submitted their plans for the use of colors and signs in mapping. Stephanesco and Rutot discussed the value of geological subdivisions and the bases of a uniform geological nomenclature for all countries, while Vilanova set forth his plan of a general dictionary of geology.

In the third session, Sterry Hunt presented a memoir on the upper and lower limits of the Cambrian series, and was followed by Barrande on the same subject. Von Mœller then discussed the constitution of the Carboniferous series in different regions of Europe, and its relations to Devonian and Permian, and was succeeded by Lesley on the same questions as presented in Pennsylvania, and by Vélain on the relations of the Trias and Lias in France.

In the fourth session, Cope discussed the relations of the horizons of fossil verebrates in Europe and America, and was followed by Albert Gaudry and by Matheson on the same subject. De Mortillet presented his views on the Quaternary formations, and Alph. Favre discussed the hypothesis of former glacial periods. Van der Broeck and Buviguier discussed the agency of meteoric phenomena in the alterations of rocks, and W. P. Blake presented and described a geological map of the United States of America. The origin of volcanoes was then considered by Virlet d'Aoust, after which the local admixtures of organic remains of different horizons, giving rise to what have been called colonies is alike in Jurassic and Devonian strata, was discussed by Choffat, Renevier and Gosselet.

In the fifth session, DesCloizeaux and Michel Lévy discussed various questions as to the feldspars in crystalline rocks, their chemical composition and microscopic character, and were followed by Sterry Hunt, on the constitution of the plagioclase feldspar, while Jannetaz treated of the geological importance of the propagation of heat in rocks, considered with reference to their structure and their origin. Sterry Hunt then gave a description of the great groups of crystalline stratified rocks found in North America, including Laurentain, Norian, Huronian, Mount Alban and Taconian, and compared them with similar groups in Europe. He was followed by Selwyn on the same subject. Szabo discussed the eruptive Tertiary rocks of Hungary, examining the question whether mineral composition can serve to show the ages of such rocks. Velaine contributed an account of the trachytes of the Reunion island and Ribeiro and of the Tertiary basalts of Portugal.

In the sixth and last session of the Congress, on the 4th of September, a communication by Bourjot was presented on the supposed eruptive limestones of Algeria, and one on some glacial phenomena of the Great Lakes district of North America, by Chamberlin, while Fuchs stated the views of several members of the Congress on the system of coloring geological maps. The President then announced the decision of the Council that the acts of the Congress are to be published in a volume under the direction of the secretaries, the cost being generously defrayed by the national government. A second International Geological Congress will be held at Bologna in Italy, in October, 1881, under the honorary presidence of Sella, president of the Accademia dei Lincei of Rome, and a local committee of ten Italian geologists has been named, charged with the organization of the Congress, of whom Prof. Capellini of Bologna will probably act as secretary. The government of the King of Italy, through the ambassador at Paris, at once promised its high patronage to the future Congress, and the municipality of Bologna sent a message of welcome.

The work of the next congress is referred to two international committees; the first of which will be charged with the unifications "des figures géologiques," that is to say, of all colors or signs employed on geological maps and plans. The second is charged with the unification of geological nomenclature, under which will be considered all questions relating to classification, as well as the value and significance of mineralogical, lithological and paleontological characters embracing the most important problems in geology. For these two international committees one member is named for each country, whose duty it will be to organize therein local committees, and to make known the composition of these as soon as possible both to the Secretary-General of the late Congress, and to the local committee of the future one. Reports by these several committees are to be sent before the first of January, 1881, to the Italian local committee of organization, who will cause them to be printed and distributed before the meeting of the Congress.

The members of the international committee on maps are as follows: United States, Lesley; Canada, Selwyn; Great Britian, Ramsay; France, de Chancourtois; Belgium, Dupont; Switzerland, Renevier; Italy, Géordano; Spain and Portugal, Ribeiro; Hungary, von Hautken; Russia, von Mœller; Scandinavia, Torell.

The international committee on nomenclature and classification is thus composed: United States, James Hall; Canada, T. Sterry Hunt; Great Britain, T. McKenna Hughes; France, Hébert; Belgium, Dewalque; Germany, Ferd. Römer; Switzerland, Alph. Favre; Italy, Capellini; Spain and Portugal, Vilanova; Hungary, Szabo; Roumania, Stephanesco; Russia, Inostranzeff; Scandinavia, Lundgren; Australia, Liversidge.

In addition to the above a local committee was named in France to discuss for the next Congress, the rules to be observed in the nomenclature of species, consisting, for paleontology, of Cotteau, Douvillé, Gaudry, Pomel, Gosselet and de Saporta, and for mineralogy and lithology, of DesCloizeaux and Jannettaz. The report of the committee of the American Association in 1876, on biological nomenclature, presented by Cope to the Congress, was referred to the above-named committee. The general language of the proceedings was of course, French, but communications made in English were interpreted by MM. Barrois and T. Sterry Hunt, and will be duly translated for the published acts of the Congress.

T. S. H.

2. *National Academy of Sciences.*—At the session of the National Academy of Sciences in New York City, November 5–8, 1878, the following papers were presented.

Henry Draper.—The Solar Eclipse of July 29, 1878.

S. H. Scudder.—The early types of insects.

C. S. Peirce.—The acceleration of gravity at initial stations.

W. P. Trowbridge.—The inapplicability of the old theory of the turbine water-wheel to the newer constructions instituted by Boyden & Francis.

A. A. Agassiz.—(1.) The embryology of the gar-pike.—(2.) Arrangement of a zoological marine laboratory at Newport, R. I.

Elias Loomis.—Contributions to Meteorology: the storms of the Atlantic Ocean.

H. L. Abbott.—(1.) Biographical memoir of Prof. D. H. Mahan.—(2.) Value of photography in the study of instantaneous phenomena, illustrated by photographs of torpedo explosions.

Benjamin Alvord.—Continuation of paper presented at the April meeting, On the intersection of circles and the intersection of spheres.

Stephen Alexander.—(1.) On the eleventh axiom of Euclid and a proposed demonstration of the same.—(2.) Recapitulation of some of the author's views on the origin of the forms and present state of many clusters of stars and of several nebulæ, the source of solar heat, and drift of the stars.—(3.) Brief notice of the total solar eclipse of January 11, 1880.—(4.) On certain modifications of the Schehallien experiments, and of the Cavendish experiment.

George Davidson.—Instruments of precision at the Paris Exposition.

J. S. Newberry.—(1.) On some remains of new fossil fishes and their relation to living forms.—(2.) On some mooted points in American Geology.

O. N. Rood.—(1.) On a quantitative analysis of white light.—(2.) Note on Henry's theory of color.

E. D. Cope.—On the characters of the Theromorphous Reptilia and Stegocephalous Batrachia.

C. A. Young.—Measures of the diameter of Mercury by a new method, made at the transit of May 6, 1878.

A. Hyatt.—Some remarks on an investigation on the laws of heridity undertaken by the Board of Health of Massachusetts.

At the same session on November 6, the Acting President submitted the following *Report of the Committee appointed to consider the Scientific Surveys of the Territories of the United States.* The Report was adopted by the Academy.

The Committee of the National Academy of Sciences, to whom has been referred the consideration of the following requirement of law contained in the Act making appropriations for Sundry Civil expenses of the Government for the fiscal year ending June 30, 1879, and for other purposes, approved June 20, 1878, namely:

"And the National Academy of Sciences is hereby required at their next meeting to take into consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department, and the surveys of the Land Office, and to report to Congress as soon thereafter as may be practicable a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost; and also to recommend to Congress a suitable plan for the publication and distribution of reports, maps. and documents, and other results of the said surveys,"

Submitted the following report:

The Committee consider that the field of inquiry proposed to the Academy is intended to embrace only such surveys as pertain to the public domain. They have not included in their plan of organization surveys and investigations, however scientific in method and character, which apply solely to engineering works, such as the improvements of rivers, harbors, lakes, etc.; the irrigation and drainage of public lands, reclamation of tidal lands, and protection of alluvial regions from floods. Such surveys and investigations, being inseparably connected with engineering problems, should, in the judgment of the Committee, be conducted by the Engineer Corps of the Army. Nor do the Committee recommend any change in the organization of the Survey of the Great Lakes, as this is now nearly completed.

The works which seem to fall especially within the limits of the meaning of the law are: the Geographical Surveys west of the one hundredth meridian, under the War Department; the United States Geographical and Geological Surveys of the Territories and of the Rocky Mountain region, under the Interior Department; and the system of Land Surveys, under the supervision of the Land Office. Besides these, although not enumerated in the law, one of the most important works now in progress in the interior, under Act of Congress, is the geodetic work of the Coast and Geodetic Survey. Parties of this organization are now conducting a systematic triangulation at several points in the interior, and any general system, such as is contemplated in the above law, cannot be wisely devised without taking into account the object and organization of this survey. The objects of these various surveys are: (1.) An accurate geodetic survey. (2.) A general geographical and topographical reconnoissance. (3.) Land parcelling surveys, on which the Government can part title to portions of the public domain. (4.) The economic classification and valuation of the public domain. To these should be added, the gradual completion of a general accurate topographical map of the whole Territory of the United States, which shall serve as a basis for all the scientific and practical needs of the Government and the people. All this work may be included under two distinct and separate heads: (1.) Surveys of mensuration. (2.) Surveys of geology, and economic resources of the soil.

We will first consider the present operations of the surveys of mensuration. Such surveys are now in progress under five different independent organizations: that of the Coast and Geodetic Survey; of the Geographical Surveys west of the one hundredth meridian, under the War Department; of the topographical work of the two surveys under the Interior Department; and of the Land Survey under the Land Office. The final object of all these works of mensuration is the accurate determination of position, and the laying down of lines and points by measurement. There is at present no coördination between these five surveys. Their original determinations of position are independent; their systems of survey discordant; their results show many contradictions, and involve unnecessary expenditure. The geographical reconnoissances carried on under the War and Interior Departments are of little value for the parcelling of land, while the land surveys are of correspondingly slight topographical and geographical value. The operations of the Coast and Geodetic Survey in the interior do not at present include topography and land parcelling. To attain the desirable accuracy, and economy, it is absolutely essential that there should be only one geodetic system, one topographical system, and one land parcelling system, all conducted under the same head. It is evident that both topographical and land parcelling surveys, to be properly coördinated and sufficiently exact, must be based upon a single rigid geodetic foundation. All these three divisions are departments of measuring; all are based upon accurate determinations of position; and, to be effectively and economically carried out, should be united into one comprehensive system.

After a careful consideration of the facilities at the disposal of the several existing organizations engaged in this work, the Committee believe that the Coast and Geodetic Survey is practically best prepared to execute the entire mensuration system required. Within the public domain, the dominant interest of the United States is centered in the public lands which remain to be surveyed and sold. The administration of these lands, consisting of 1,101,107,183 acres, is necessarily within the Department of the Interior, while the Coast and Geodetic Survey, having been originally inaugurated to meet the wants of commerce, has been hitherto under the Treasury Department. In view of the paramount importance of the public lands, the Committee recommend that the Coast and Geodetic Survey be transferred from the Treasury Department to the Department of the Interior, retaining its original field of operations, and assuming, also, the entire mensuration of the public domain; and that, so modified and extended, it hereafter be known as the United States Coast and Interior Survey. This organization would then embrace, in addition to its former work, a geodetic survey of the whole public domain, a topographical survey comprising detailed topographical work and rapid reconnoissance, and land parcelling surveys.

The Superintendent of the Coast and Interior Survey should be appointed by the President, and should report directly to the Secretary of the Interior.

The best interests of the public domain require for the purposes of intelligent administration a thorough knowledge of its geological structure, natural resources, and products. The domain embraces a vast mineral wealth in its soils, metals, salines, stones, clays, etc. To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert, and swamp lands, a thorough investigation and classification of the acreage of the public domain is imperatively demanded. The Committee, therefore, recommend that Congress establish, under the Department of the Interior, an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geological structure and economic resources of the public domain; such survey to be placed under a Director, who shall be appointed by the President, and who shall report directly to the Secretary of the Interior.

It should be specially provided that the Director and members of the Geological Survey, charged as they are with the investigation of the natural resources of the public domain, shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations.

Officers of the Army and Navy, when not otherwise employed, might be detailed by the Secretary of War or of the Navy to take part in the operations of either survey.

With the inauguration of the two surveys above defined, the Committee recommend a discontinuance (1) of the present Geographical and Geological Surveys west of the one hundredth meridian, under the War Department, except surveys necessary for military purposes and local internal improvements; (2) of the Geographical and Geological surveys now in progress under the Department of the Interior; and (3) the present Land surveys under the Land Office.

The effect of the above changes will be to maintain within the Interior Department three distinct organizations; (1) the Coast and Interior Survey, whose function will embrace all questions of position and mensuration; (2) the United States Geological Survey, whose function will be the determination of all questions relating to the geological structure and natural resources of the public domain; (3) the Land Office, controlling the disposition and sale of the public lands, including all questions of title and record. With this division should be secured a perfect coördination and coöperation between the three branches. The Land Office should call upon the Coast and Interior Survey for all surveys and measurements required for the sale and disposition of land. The Land Office should also call upon the United States Geological Survey for all information as to the value and classification of lands. The results of all the mensuration surveys, as soon as completed, should be immediately available for the Land Office, and for the Geological Survey, and for other branches of the Government as required. The Geological Survey should be authorized to execute local topographical surveys for special purposes, such, for instance, as the subterraneous surveys of mining districts and metallic deposits, etc.

Each of the three organizations, thus defined, should make an annual report of its operations to the Secretary of the Interior. The publications of the Land Office should embrace reports of its business operations relating to the disposition and sale of land, together with the necessary maps. The publications of the Coast and Interior Survey, besides the annual report of operations, should consist of its geodetic results, geographical, topographical and cadastral maps, coast charts, and such discussions and treatises connected therewith as the Superintendent shall deem of value. The publications of the Geological Survey should consist of an annual report of operations, geological and economic maps illustrating the resources and classification of the land, reports upon general and economical geology in all its branches, with the necessarily connected paleontology.

All collections made by the Coast and Interior, and the Geological Surveys, when no longer needed for the investigations in progress, should be transferred to the National Museum.

The Committee recommend that, upon the organization of the United States Coast and Interior Survey and the United States Geological Survey, a commission be formed, to consist of the Commissioner of the Land Office, Superintendent of the Coast and Interior Survey, Director of the United States Geological Survey, the Chief of Engineers of the Army, and three other persons to be appointed by the President, who shall take into consideration the codification of the present laws relating to the survey and disposition of the public domain; and who shall report to Congress within one year a standard of classification and valuation of the public land, together with a system of land parcelling survey. The necessity of this commission is evident from the fact that by far the larger part of the public domain lies in the region where, from geological and climatic causes, the lands are for the most part not valuable for field-culture; and where the system of homestead preëmption and sale in accordance with existing laws is both impracticable and undesirable.

In regard to publications of the two surveys above defined, the Committee recommend that, besides the number of copies of each report which Congress may order for its own distribution, three thousand copies be published, for scientific exchanges by the heads of these surveys, and for sale at the price of publication; that all literary and cartographic material received by the heads of these surveys in exchange be the property of the United States, and form a part of the libraries of the two organizations; that the money resulting from the sale of these publications be covered into the Treasury. The Committee recommend that the annual reports of operations of the two surveys accompany the report of the Secretary of the Interior; that the special memoirs and reports of both surveys be issued in uniform quarto series; that the style and scale of the cartographic publications be determined by the head of each organization, so as to express the scientific results in the most effective and economical manner.

All of which is respectfully submitted:

O. C. MARSH, *Vice President, and Acting President.*

JAMES D. DANA, WILLIAM B. ROGERS, J. S. NEWBERRY, W. P. TROWBRIDGE, SIMON NEWCOMB, ALEX. AGASSIZ, *Members of the Committee.*

[This Report was submitted to Congress at the opening of the present session and referred to the Committee on Appropriations.]

3. *New York Academy of Sciences.*—Nos. 1 to 4 of the Annals of the New York Academy of Sciences (late Lyceum of Natural History), extending to 128 pages, 8vo, have been published. They contain papers by H. C. Bolton, on the application of organic acids to the examination of minerals; on prehistoric Bronze bells from Japan, by H. S. Munroe; on the variations in Lepidodendron and Sigillaria, by H. L. Fairchild; on new species of Birds, by G. N. Lawrence; on the literature of titanium, by E. J. Hallock; on new fossils of the Upper Silurian of Port Jervis, by S. F. Barrett; on new fossil fishes of the Trias, by J. S. Newberry; and they are illustrated by nine plates, six of them by H. L. Fairchild. Dr. Newberry describes *Diplurus longicaudatus*, from Boonton, N. J., and *Ptycholepis Marshii*, from Durham, Conn.

4. *Anales de la Oficina Meteorologica Argentina;* por su Director, B. A. GOULD. Tome 1. Clima de Buenos Ayres. 4to, pp. 523, and 17 plates. Buenos Ayres, 1878.—This first volume of Annals of the Meteorological Bureau of the Argentine Republic contains the first four annual reports of the Director. Following these are tables exhibiting the peculiarities of the climate of the city of Buenos Ayres. The materials for this discussion are quite full records of meteorological observations since 1856, and less complete ones during scattered years from 1801 to 1856. The principal part of the computations were made by Dr. Gutermann. The results are very fully exhibited in the plates. In the future volumes of the Annals, Dr. Gould expects to give the observations made at numerous other points in the Republic, with discussions of them.

5. *Science News.*—A new scientific periodical, under the editorship of Ernest Ingersoll and W. C. Wyckoff, and published fortnightly by S. E. Cassino, at Salem, Mass. Each number is to contain at least sixteen pages octavo of reading matter, and its peculiar feature is stated to be "the prompt publication of scientific news." No. 1 (November 1st), contains short articles by Dr. C. C. Abbott, Professor F. W. Clarke, Dr. Elliott Coues and others; Nos. 2 and 3 are chiefly occupied with abstracts of papers read at the recent meeting of the National Academy of Sciences.

6. *An American Geological Railway Guide, giving the geological formation at every railway station, with notes on interesting places on the routes, and a description of each of the formations;* by JAMES MACFARLANE, Ph.D. 216 pp. 8vo. New York,

1879. (D. Appleton & Co.)—The scope and general object of this work are well stated in the above title. It occupies a decidedly new place among handbooks of travel and contains a great amount of information in a very condensed form.

7. *Essentials of Chemistry, Inorganic and Organic, for the use of Students in Medicine;* by R. A. WITTHAUS. New York, 1879. 18mo, pp. 257. (William Wood & Co.)—The author has skillfully condensed the "Essentials of Chemistry," for the Medical student, into a vest-pocket catechism, which fulfills well the object for which his little volume has been prepared.

8. *Handbook of Alabama:* A complete index to the State; with a geological map and an Appendix of useful tables, by SAFFOLD BERNEY.—This volume contains a valuable outline of the geology of Alabama, with a geological map of the State, by Eugene A. Smith, Ph.D., State Geologist.

The Amateur's Handbook of practical Information for the Workshop and the Laboratory: containing directions for bronzing, lacquering, polishing metal, etc. 44 pp. 12mo. New York, 1878. (The Industrial Publication Company).

On the Structure of the Stylasteridæ. A family of Hydroid Stony Corals, by H. N. Moseley, F.R.S., late Naturalist on board H. M. S. Challenger. (From the Philosophical Transactions of the Royal Society, Part II, 1878.

Annual Report of the Chief Signal Officer to the Secretary of War for the year 1877. 570 pp. 8vo, with 34 maps and 18 charts. Washington, 1877.

Description of eight new species of Holocystites from the Niagara Group, by S. A. Miller. The new species are: *H. Brauni*, *H. Wetherbyi*, *H. ornatus*, *H. perlongus*. *H. globosus*, *H. pustulosus*, *H. plenus*, *H. elegans;* they are from Jefferson and Ripley counties, Indiana.

Remarks on some Lamellibranchiate Shells of the Hudson River Group by R. P. Whitfield. The new species are: *Cypricardites quadrangularis*, *Cuneamya curta*, *Orthodesma Mickleboroughi*, *Sedgwickia* (?) *lunulata;* locality, Clinton Co., Ohio.

A Handbook of the Electric Telegraph, by A. E. Loring. 98 pp. 12mo. New York, 1878 (Van Nostrand's Science Series).

Statistical Sketch of South Australia, by Josiah Boothby. 86 pp. 8vo. London, 1876. Published by authority of the Government. (Sampson Low, Marston, Searle, & Rivington, London.)

The American Antiquarian: a Quarterly Journal devoted to Early American History, Ethnology, and Archæology. Edited by Rev. Stephen D. Peet, of Unionville, Ohio. Published by Brooks, Schinkel & Co., Cleveland, Ohio.—Vol. i, No. 2, July, August and September, 1878.

A Monograph of the Silurian Forests of the Girvan District in Ayrshire, by H. Alleyne Nicholson and Robert Etheridge, Jr. Fasciculus I. Rhizopoda, Actinozoa, Trilobita. 135 pp. 8vo, with ix plates. Edinburgh and London, 1878. (William Blackwood & Sons.)

Report on the Meteorological Service of the Dominion of Canada, by the Superintendent; to which is appended the Report of the Directors of the Magnetic and other Observatories, for the year ending December 31st, 1877. Ottawa, 1879.

APPENDIX.

ART. IX.—*A new Order of Extinct Reptiles* (SAURANODONTA), *from the Jurassic Formation of the Rocky Mountains;* by Professor O. C. MARSH.

THE absence of the genus *Ichthyosaurus* in the extinct fauna of this country has long been a noteworthy feature, for up to the present time no traces of it have been detected, although its remains are especially abundant in Europe. An interesting specimen recently discovered in the Rocky Mountain region presents, in most of its skeleton, the characteristics of that genus, but is *without teeth.* The vertebræ, ribs, and other portions of the skeleton preserved, cannot be distinguished from the corresponding parts of *Ichthyosaurus*, and many features of the skull show a strong resemblance. The general form of the skull is the same. The great development of the premaxillaries; the reduced maxillaries; the huge orbit defended by a ring of bony plates, are all present, but the jaws appear entirely edentulous, and destitute even of a dentary groove.

The proportions of this reptile were very similar to those of *Ichthyosaurus.* The skull is about two feet (600^{mm}) in length, and the facial portion especially produced. The orbits are very large, and the space between them is 140^{mm}. The sclerotic ring is composed of only eight plates. Its diameter at the base is 106^{mm}, and at the apex 58^{mm}. These plates are not arranged in a nearly flat ring, as in *Ichthyosaurus*, but form the basal segment of an elongated cone, as in the eyes of some birds. The vertebræ are short, and deeply bi-concave. The neural arch is articulated to the centrum. One trunk vertebra measures 85^{mm} in width, 38^{mm} in length on the floor of the neural canal, and 21^{mm} between the centers of the two rib articular faces of the same side. The length of the entire animal was about eight or nine feet. The remains at present known are all in the Museum of Yale College.

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This reptile may be called *Sauranodon natans*, and the order it represents *Sauranodonta*. This genus bears a similar relation to the Ichthyosaurs that *Pteranodon* does to the true Pterodactyls, and it is interesting to find the two highly specialized forms preserved in the same region.

The geological horizon of the *Sauranodontidæ*, so far as now known, is in the Jurassic, immediately below the Atlantosaurus beds. The accompanying fossils are Ammonites and Belemnites, showing more distinctly marine deposits, which may be called the Sauranodon beds.

Yale College, New Haven, December 27, 1878.

ART. X.—*Principal Characters of American Jurassic Dinosaurs;* by Professor O. C. MARSH. Part II. With eight Plates.

IN a previous article (vol. xvi, p. 411, Nov., 1878), the writer gave a short account of the geological horizon and accompanying fossils of the Jurassic Dinosaurs recently found in the Rocky Mountains; and also stated the more important characters of the gigantic *Sauropoda*, as illustrated mainly by the genus *Morosaurus*. In the present communication, this group is further elucidated by a comparison of the structure in some other American genera, especially *Apatosaurus* and *Atlantosaurus*, to which belong the largest reptiles hitherto discovered. The carnivorous enemies of this group are also briefly described. The pelvis of Dinosaurians, hitherto so little known, is illustrated by new examples, and by the corresponding parts in some recent birds.

Apatosaurus Marsh, 1877.*

The genus *Apatosaurus* may be readily distinguished from *Morosaurus* by the sacrum, which consists of only three vertebræ instead of four (Plates V and VI, figures 1 and 2.) The ischium, also, has its distal end expanded. The scapula, likewise, is quite different, its superior extremity, being without the anterior extension seen in *Morosaurus* (Plate IV.) So far as at present known, the latter character, together with the form of the sacrum, separates it from the allied genus *Atlantosaurus*.

The cervical vertebræ of *Apatosaurus* are strongly opisthocœlian, and of moderate length. (Plate III, figures 1 and 2.) The dorsals have their centra similar, and both have deep cavities in the sides and in the neural arch resembling those in the corresponding vertebræ of *Morosaurus*. The lumbar vertebræ have their articular faces more nearly plane, and the last lumbar is expanded transversely. The sacrum is characteristic of the genus, and quite unlike any hitherto known. The type specimen on which the genus was established is well shown in Plate VI, figure 1. It is short and massive, and the three vertebræ which form it are nearly equal in size and general proportions. They are firmly coössified, and their transverse processes are ankylosed to the centra. Those on each side are united distally into a solid mass, which rests on the short ilium. The articular faces of the sacral vertebræ are nearly plane. That of the anterior centrum is a transverse oval in outline, and the posterior face is more nearly round. The centra and their processes are somewhat lightened by cavities, as in the sacra of *Atlantosaurus* and *Morosaurus*. The sacrum of the latter genus, shown in figure 2 of Plate V, is built upon the same general plan, characteristic of the *Sauropoda*, but the transverse processes are less massive, and have a greater vertical elevation. The same sacrum is shown in position in Plate V, figure 1. A striking feature of this sacrum is seen in the large size of the neural canal (*nc*), which, strange to say, is here two or three times the diameter of the brain cavity. This is a most suggestive fact, and without parallel in known vertebrates.

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* This Journal, vol. xiv, p. 514.

The scapula of *Apatosaurus* is large (Plate IV), and has in its lower portion an anterior projection similar to that in *Morosaurus*.* Above this, the shaft continues about the same width to the upper end, which is comparatively thin. The coracoid is small in proportion to the scapula, and subquadrate in outline, thus differing in form from that of *Morosaurus*. The foramen is large, and near the superior border.

There is at present some difficulty in separating the limb bones and various other parts of the skeleton of *Apatosaurus* from the corresponding portions of *Atlantosaurus*, especially as the type species of each are nearly equal in size, and their remains are found in the same localities. The sacra show the genera to be quite distinct, and the abundant material now in the Yale Museum, when carefully collated, will enable other parts of the structure to be compared. The teeth in all the herbivorous genera of the *Sauropoda* from the Atlantosaurus beds, so far as now known, appear to be very similar, and hence do not afford generic characters.

The type species of the present genus is *Apatosaurus ajax* Marsh, and the known remains indicate a reptile at least fifty feet in length. A much larger species is indicated by various remains from the same locality in Colorado, among which is the huge cervical vertebra represented in Plate III, figures 1 and 2. This species had a short massive neck, and hence may be called *Apatosaurus laticollis.* The size of the entire animal may be judged from this vertebra, which measures over three and a half feet (1·07 M) in width. This would imply a neck at this point not less than five or six feet wide,—a marked contrast to the long and slender neck of *Morosaurus grandis*, a vertebra of which is figured in the same plate for comparison. All the cervical vertebræ of the present species now known are unusually short, and the neural spine is rudimentary or wanting. With the exception of the articular faces of the centra, the resemblance of these cervicals to those in some birds is very striking.

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* This Journal, vol. xvi, Plate VI.

The limb bones at present referred to this species have a general resemblance to those of *Morosaurus*, described by the writer in the previous article. The pelvic bones appear to be more like those of *Atlantosaurus.*

The more important remains of this genus now known were found in the Upper Jurassic of Colorado, by Mr. Arthur Lakes, of the Yale Museum, to whom science is indebted for other interesting discoveries.

Atlantosaurus Marsh, 1877.*

The typical species of this genus is *Atlantosaurus montanus*, and the type specimen on which it was based is represented by the sacrum figured in Plate VI, and various fragmentary remains found with it, and pertaining to the same individual. This sacrum resembles that of *Morosaurus* (Plate V, figure 2), in having four vertebræ, but a comparison of the two shows many differences. The centra of the second and third vertebræ are deeply excavated below on each side, leaving a comparatively narrow keel on the median line. From each opening between the transverse processes, a large cavity extends inward and backward into the centra, greatly lessening the weight of the sacrum. These important characters were mentioned in the original description, (vol. xiv, p. 87, July, 1877), in which the discovery of these large reptiles was first announced.

The ilium in *Atlantosaurus* is comparatively short and massive, but its exact outline has not been fully determined. Its articulations resemble those in the ilium of *Morosaurus*, and in the pelvis represented in Plate VII, figure 2, the outline of this bone is restored from that genus. The pubis is somewhat like that in *Morosaurus*, and its position in the pelvis very similar. It has three distinct articular faces on its proximal end, and, below the ischiadic union, a post pubic projection indicated in the diagram by *p′*. The distal end is expanded, and rugose for union with its fellow on the median line, as shown in the pelvic arch of *Morosaurus*, in Plate V, figure 1. The ischium is less massive than the pubis, and it is directed downward, backward and inward. The acetabular face is larger than that of the pubis. The shaft of the ischium is not curved as in *Morosaurus*, and the distal end is widely expanded, and unites with its fellow on the median line, in a strong symphysis. The difference in the pelves of the two genera are well shown by a comparison of the figures in Plate VII. The ischium of *Morosaurus* is somewhat more twisted in its distal half than the artist has drawn it in figure 1, where the three bones are represented nearly in the same plane.

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* This Journal, vol. xiv, p. 514. Also p. 87.

The vertebræ referred to *Atlantosaurus* are opisthocœlian in the cervical region, and the caudals preserved resemble those in *Morosaurus*. The limb bones, so far as known, are similar in their more important characters to those in that genus.

The two species now placed in the genus *Atlantosaurus* are the type, *A. montanus*, and *A. immanis*, which contain the largest land animals yet discovered. The latter species may possibly belong to the genus *Apatosaurus*.

The genera of *Sauropoda* above described and figured, viz: *Morosaurus*, *Diplodocus*, *Apatosaurus* and *Atlantosaurus*, show this suborder to be a well marked and natural group, the most generalized of the Dinosaurs. Some other generic names have been given to members of this group by Cope, which I shall review at another time. He still places the horizon of these reptiles in the Cretaceous, although the evidence of their Jurassic age seems now conclusive. In one species which he calls *Camarasaurus supremus* (identical according to Professor Owen with his genus *Chondrosteosaurus* from the English Wealden),† he says, in the sacrum, "the centra are like those of the caudal vertebræ composed of dense bone,"‡ a statement wholly discordant with the known characters of the group. He likewise describes the diplosphenal articulation of the vertebræ as unknown, and states (page 76) that it "has not been observed in any other animals;" whereas it has long been known in *Megalosaurus*, one of the earliest Dinosaurs described, as well as in other genera. The pelvic bones of this species, he says, do not resemble those of *Dinosauria*, when, on the contrary, the pubis he figures is typical in the group. Conclusions based on such work will naturally be received with distrust by anatomists.

Allosauridæ.

In addition to the huge *Sauropoda*, and the small species of the genus *Laosaurus*, described in the previous article, numerous remains of carnivorous Dinosaurs occur in the same beds, and indicate the natural enemies which kept in check their herbivorous cotemporaries. These carnivorous forms represent two very distinct families; the *Allosauridæ*, resembling in many respects *Megalosaurus* and its near allies; and the *Nanosauridæ*, a widely different group, which appears to have some affinities with *Compsognathus*. In the present article, the former group is briefly discussed, and both will be more fully described in a future communication.

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† Annals and Mag. Nat. Hist., vol. ii, p. 201, Sept., 1878.
‡ Am. Naturalist, vol. xii, p. 77.

The genus *Allosaurus* is typical of the family, which also includes *Creosaurus*, and *Labrosaurus*. The first named genus presents some very interesting features in the vertebræ, and pelvic arch. The vertebræ first described are remarkable for the reduction of the centrum by constriction, so that the requisite lightness is secured without cavities in the interior. This is shown in the lumbar vertebra represented in Plate X, figures 3 and 4. The diplosphenal articulation of the zyapophyses, seen in the corresponding vertebræ of *Megalosaurus*, and in some other Dinosaurs, is well marked in these vertebræ.

The sacrum in *Allosaurus* apparently contains four vertebræ only, and these have very short and stout transverse processes, not united at their distal ends. These processes are coössified with the sides of the centra, and their extremities are obliquely truncated for union with the ilia, which thus stand nearly vertical, or somewhat divergent above. The exact form of the ilium is not known with certainty, and in the diagram given in Plate VIII, figure 2, the outline is taken from the ilium of *Creosaurus*. The pubis is perhaps the most remarkable bone in the skeleton, and its determination and position solve many difficulties in the structure of the Dinosaurian pelvis, especially in the Carnivorous types. At its proximal end, this bone has four well-marked articular faces; one in front for the ilium; next the acetabular face; an oblique face for the ischium; and below this another, of about equal size, to which a separate bone was apparently articulated. Judging from the structure of the pelvis in *Laosaurus*, this bone should be the postpubis, and it is so indicated in the figure (Plate VIII, figure 2, *p'*). The shaft of the pubis is slender, and the distal end is expanded longitudinally, and firmly coössified with its fellow. The two seen from the front resemble an acute letter V. This type of pubic bone has long been a puzzle to anatomists, and portions of it have been referred to various parts of the skeleton. The ischia, also, are closely united on the middle line throughout the distal half, but are not ankylosed. This makes the entire pelvic arch a remarkably narrow one.

The large bones in *Allosaurus* are hollow, and the metatarsals slender. The terminal phalanges were armed with sharp claws. With the remains described above, a large spine was found, similar in general form to that of *Omosaurus armatus* described by Owen.

The type of *Allosaurus* is *A. fragilis*,* the remains of which indicate a reptile probably twenty-five feet in length, and of slender proportions.

The genus *Creosaurus* appears to be most nearly related in its vertebræ and ilium to *Megalosaurus*. It has apparently one less vertebra in its sacrum, and the ilium has in front of its pubic process an articular face which has not been observed in the latter genus. The position of this surface is indicated in Plate X, figure 1, *f*, and it may have supported a prepubic bone. The sacral vertebræ are elongated, and the transverse processes are placed higher up on the centra than those in *Allosaurus*. The teeth in both genera are of the *Megalosaurus* type, and in the whole group are so similar as to be of little value for the determination of species. The type of *Creosaurus*, is *C. atrox*,† a reptile about twenty feet in length.

A third genus of carnivorous Dinosaurs contains individuals of somewhat smaller size, and of this group the species named *Allosaurus lucaris*‡ is the type. The cervical vertebræ are short and strongly opisthocœlian, and the dorsals moderately so. All these vertebræ have very large cavities in the centra, which connect with the exterior by a comparatively small foramen on each side. The neural spines of the dorsal vertebræ are elevated and transverse, and the vertebræ now known do not show the diplosphenal articulation. The fore limbs in this genus are quite small, and the humerus is curved, and has a large radial crest. This genus is distinct fron *Allosaurus*, and may be called *Labrosaurus*, the type being *Labrosaurus lucaris*.

All of the carnivorous Dinosaurs known from the Atlantosaurus beds appear to have moved mainly on the posterior limbs. The large bones were hollow, and many of the vertebræ, as well as some of the feet bones, contained cavities, or were otherwise lightened to facilitate rapid movement.

The reptilian remains described in these two communications are preserved in the Museum of Yale College. In addition to these fossils, the collection contains a large quantity of similar specimens, from the same localities and horizon, some of which pertain to the same skeletons as those here illustrated. The careful investigation of this entire series will require much time, but promises important results.

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* This Journal, vol. xiv, p. 515. † Ibid., vol. xv, p. 243.

‡ Ibid., vol. xv, p. 242.

The descriptions and illustrations given in this and the preceding article make clear the general structure of the Dinosaurian pelvic arch, which has so long been in doubt. In the *Sauropoda*, the elements of this arch are seen united in forms that admit of direct comparison with other more typical reptiles, each genus of the group having its own special features. In the smaller, more specialized, herbivorous forms, exemplified by *Laosaurus*, an advance is seen, especially in the pubic elements, where the long rod-like avian bone is fully developed, and the anterior part, or true reptilian pubis, is still prominent. In the Carnivorous forms represented by *Allosaurus*, a more complicated structure is seen to exist, but additional material will be necessary to elucidate it fully. In the pelves of the recent birds, given in Plate IX, the remnant of the reptilian pubis is still plainly to be seen, especially in *Geococcyx*. It is not improbable that the retention of this process may be due in part to the habits of certain species, as it seems to be best developed in running birds, and those that especially use the posterior limbs. The same process, apparently, is seen in some mammals, where it may serve a similar purpose. The ilium and ischium undergo but comparatively little change from the *Sauropoda* to recent birds. The sacrum, however, is gradually strengthened by the addition of vertebræ, and their more perfect coössification.

Yale College, New Haven, December 27, 1878.

[To be continued.]

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[THIRD SERIES.]

Art. XI.—*Discussion of the Working Hypothesis that the so-called Elements are Compound Bodies*;* by J. Norman Lockyer, F.R.S.

It is known to many Fellows of the Society that I have for the last four years been engaged upon the preparation of a map of the solar spectrum on a large scale, the work including a comparison of the Fraunhofer lines with those visible in the spectrum of the vapor of each of the metallic elements in the electric arc.

To give an idea of the thoroughness of the work, at all events in intention, I may state that the complete spectrum of the sun, on the scale of the working map, will be half a furlong (330 ft.) long; that to map the metallic lines and purify the spectra in the manner which has already been described to the Society, more than 100,000 observations have been made and about two thousand photographs taken.

In some of these photographs we have vapors compared with the sun, in others vapors compared with each other; and others again have been taken to show which lines are long and which are short in the spectra.

I may state in way of reminder that the process of purification consisted in this: When, for instance, an impurity of manganese was searched for in iron, if the longest line of Mn was absent, the short lines must also be absent on the hypothesis that the elements are elementary; if the longest line was present, then the impurity was traced down to the shortest line present.

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* Paper read at the Royal Society, December 12, 1878.

TABLE I.—FINAL REDUCTION—IRON.

Intensity in Sun.	Wave-length and length of line.	Coincidences with Short Lines.																		
1	39 0600 2	U 3	Zr 5	Yt 4																
3	0622 4				Va 4															
2	0920 3				Va 2	Ba 3														
3	1010 4				Va 4		Pt 3													
2	1648 2							Co 3												
2	1755 3								Mn 3	Ce 4										
2	1835 4										Os 2									
1	2700 1				Va 2															
1	2950 1											Mo 3								
3	3023 4									Ce 4										
5	3435 4	U 2																		
3	3475 2					Ba 2							Rh 2							
3	3628 3													Ta 3						
2	3975 2							Co 3												
3	4026 3				Va 5															
3	4422 4											Mo 3								
3	4720 2			Yt 5											Th 3					
2	5012 2															Di 2				
2	5160 2									Ce 3							Ru 3			
2	5210 3																	W 3		
2	5423 4	U 3										Mo 3						W 4		
3	6215 3			Yt 5						Ce 3						Di 2				
2	6571 2		Zr 2																	
3	6662 2														Th 1					
1	7555 3										Os 2			Ta 4					Cr 2	
3	7578 4															Di 2				
2	7685 2				Va 4															
2	8083 2																			Ti 1
1	8320 1																		Cr 3	
3	9520 3																Ru 3			
2	9750 2											Mo 3								

TABLE II.—FINAL REDUCTION—TITANIUM.

Intensity in Sun.	Wave-length and length of line.	Coincidences with Short Lines.												
1	39 0000 3	Zr 4												
4	0048 3		Th 4											
5	1040 5			Mn 4	Ce 5	Di 3								
2	1360 3						Va 4							
5	1915 8				Ce 4									
4	2050 3							U 3		La 3				
3	2368 2						Va 3							
3	3718 5		Th 4		Ce 4									
2	4775 1								Fe 2					
2	5722 1	Zr 1									Rh 3			
4	6175 2							U 3						
3	6335 2					Di 3						Ta 5		
2	8083 1								Fe 2					
3	8152 2												Mo 3	
1	8922 1			Mn 4										Cr 4
2	9878 longest						Va longest							

The Hypothesis that the Elements are Simple Bodies does not include all the Phenomena.

The final reduction of the photographs of all the metallic elements in the region 39–40, a reduction I began in the early part of the present year, and which has taken six months, summarized all the observations of metallic spectra, compared with the Fraunhofer lines, accumulated during the whole period of observation. Now this reduction has shown me that the hypothesis that identical lines in different spectra are due to impurities is not sufficient. I shall show in detail in a subsequent paper the hopeless confusion in which I have been landed. I limit myself on the present occasion to giving tables showing how the hypothesis deals with the spectra of iron and titanium.

We find short line coincidences between many metals the impurities of which have been eliminated or in which the freedom from mutual impurity has been demonstrated by the absence of the longest lines.

Evidences of Celestial Dissociation.

It is five years since I first pointed out that there are many facts and many trains of thought suggested by solar and stellar physics which point to another hypothesis—namely, *that the elements themselves, or at all events some of them, are compound bodies.*

In a letter written to M. Dumas, December 3, 1873, and printed in the Comptes Rendus, I thus summarized a memoir which has since appeared in the Philosophical Transactions.

> "Il semble que plus une étoile est chaude plus son spectre est simple, et que les éléments métalliques se font voir dans l'ordre de leurs poids atomiques.[*]
>
> "Ainsi nous avons:
>
> "1. Des étoiles très-brillantes où nous ne voyons que l'hydrogène, *en quantité énorme*, et le magnésium;
>
> "2. Des étoiles plus froides, comme notre Soleil, où nous trouvons:
>
> $$\mathrm{H}+\mathrm{Mg}+\mathrm{Na}$$
> $$\mathrm{H}+\mathrm{Mg}+\mathrm{Na}+\mathrm{Ca},\ \mathrm{Fe},\ \ldots\ ;$$
>
> dans ces étoiles, pas de métalloïdes;
>
> "3. Des étoiles plus froides encore, dans lesquelles *tous les éléments métalliques sont* ASSOCIÉS, où leurs lignes ne sont plus visibles, et où nous n'avons que les spectres des métalloïdes et des composés.
>
> "4. Plus une étoile est âgée, *plus l'hydrogène libre disparaît;* sur la terre, nous ne trouvons plus d'hydrogène en liberté.
>
> "Il me semble que ces faits sont les preuves de plusieurs idées émises par vous. J'ai pensé que nous pouvions imaginer une '*dissociation céleste*,' qui continue le travail de nos fourneaux, et que les métalloïdes sont des composés qui sont dissociés par la température solaire, pendant que les éléments métalliques monatomiques, dont les poids atomiques sont les moindres, son précisément ceux qui résistent, même à la température des étoiles les plus chaudes."

Before I proceed further, I should state that while observations of the sun have since shown that calcium should be introduced between hydrogen and magnesium for that luminary, Dr. Huggins' photographs have demonstrated the same fact for the stars, so that in the present state of our knowledge, independent of all hypotheses, the facts may be represented as follows:—

Hottest Stars	Lines of	$\mathrm{H}+\mathrm{Ca}+\mathrm{Mg}$	
Sun		$\mathrm{H}+\mathrm{Ca}+\mathrm{Mg}+\mathrm{Na}+\mathrm{Fe}$	
Cooler Stars		— — $\mathrm{Mg}+\mathrm{Na}+\mathrm{Fe}+\mathrm{Bi}+\mathrm{Hg}$	
Coolest	Fluted bands of	— — — — — —	Metalloids.

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[*] This referred to the old numbers in which $\mathrm{Mg}=12$, $\mathrm{Na}=23$.

Following out these views, I some time since communicated a paper to the Society on the spectrum of calcium, to which I shall refer more expressly in the sequel.

Differentiation of the Phenomena to be observed on the two Hypotheses.

When the reductions of the observations made on metallic spectra, on the hypothesis that the elements were really elementary, had landed me in the state of utter confusion to which I have already referred, I at once made up my mind to try the other hypothesis, and therefore at once sought for a critical differentiation of the phenomena on the two hypotheses.

Obviously the first thing to be done was to inquire whether one hypothesis would explain these short line coincidences which remained after the reduction of all the observations on the other. Calling for sake of simplicity the short lines common to many spectra *basic lines*, the new hypothesis, to be of any value, should present us with a state of things in which basic molecules representing bases of the so-called elements should give us their lines, varying in intensity from one condition to another, the *conditions* representing various compoundings.

Suppose A (nickel, let us say) to contain B (cobalt) as an impurity and as an element, what will be the difference in the spectroscopic result?

A in both cases will have a spectrum of its own;

B as an impurity will add its lines according to the amount of impurity, as I have shown in previous papers.

B as an element will add its lines according to the amount of dissociation, as I have also shown.

The difference in the phenomena, therefore, will be that, with gradually increasing temperature, the spectrum of A *will fade*, if it be a compound body, as it will be increasingly dissociated, and it *will not* fade if it be a simple one.

Again, on the hypothesis that A is a compound body, that is, one compounded of at least two similar or dissimilar molecular groupings, then the longest lines at one temperature will not be the longest at another, the whole fabric of "impurity elimination," based upon the assumed single molecular grouping, falls to pieces, and the origin of the basic lines is at once evident.

This may be rendered clearer by some general considerations of another order.

General Considerations.

Let us assume a series of furnaces A . . . D, of which A is the hottest.

Let us further assume that in A there exists a substance *a* by itself competent to form a compound body *β* by union with itself or with something else when the temperature is lowered.

Then we may imagine a furnace B in which this compound body exists alone. The spectrum of the compound *β* would be the only one visible in B, as the spectrum of the assumed elementary body *a* would be the only one visible in A.

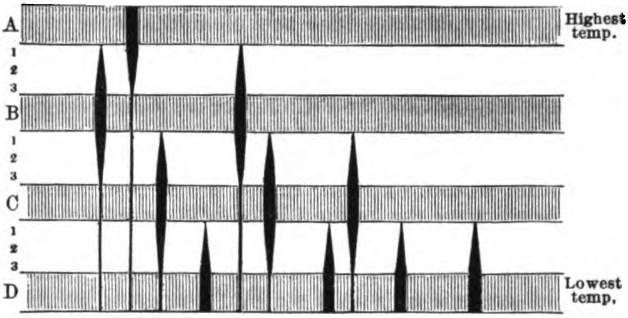

Fig. 1.

A lower temperature furnace C will provide us with a more compound substance *γ*, and the same considerations will hold good.

Now if into the furnace A we throw some of this doubly compound body *γ* we shall get at first an integration of the three spectra to which I have drawn attention; the lines of *γ* will first be thickest, then those of *β*, and finally *a* would exist alone, and the spectrum would be reduced to one of the utmost simplicity.

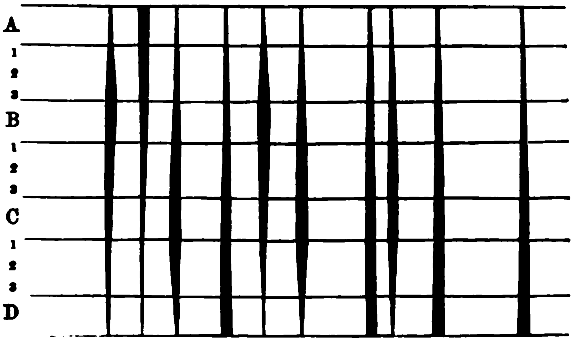

Fig. 2.

This is not the only conclusion to be drawn from these considerations. Although we have by hypothesis *β*, *γ* and *δ*, all higher, that is, more compound forms of *a*, and although the strong lines in the diagram may represent the true spectra of these substances in the furnaces B, C and D, respectively, yet, in consequence of incomplete dissociation, the strong lines of β will be seen in furnace C, and the strong lines of γ will be seen in furnace D, *all as thin lines.* Thus, although in C we have no line which is not represented in D, the intensities of the lines in C and D are entirely changed.

In short, the line of a, strong in A, is *basic* in B, C and D, the lines of β, strong in B, are *basic* in C and D, and so on.

I have prepared another diagram which represents the facts on the supposition that the furnace A, instead of having a temperature sufficient to dissociate β, γ and δ into a is far below that stage, although higher than B.

It will be seen from this diagram that then the only difference in the spectra of the bodies existing in the four furnaces would consist merely in the relative thicknesses of the lines. The spectra of the substances as they exist in A would contain as many lines as would the spectra of the substances as they exist in D; each line would in turn be basic in the whole series of furnaces instead of in one or two only.

Applications of these General Considerations to Impurity Elimination.

Now let us suppose that in the last diagram (fig. 2) the four furnaces represent the spectra of say, iron, broken up into different finenesses by successive stages of heat. It is first of all abundantly clear that the relative thicknesses of the iron lines observed will vary according as the temperature resembles that of A, B, C, or D. The positions in the spectra will be the same, but the intensities will vary; this is the point. The longest lines, represented in the diagram by the thickest ones, will vary as we pass from one temperature to another. It is on this ground that I have before stated that the whole fabric of impurity elimination must fall to pieces on such an hypothesis. Let us suppose, for instance, that manganese is a compound of the form of iron represented in furnace B, with something else; and suppose again that the photograph of iron which I compare with manganese represents the spectrum of the vapor at the temperature of the furnace D. To eliminate the impurity of iron in manganese, as I have eliminated it, we begin the search by looking for the longest and strongest lines shown in the photograph of iron, in the photograph of manganese taken under the same conditions. I do not find these lines. I say, therefore, that there is no impurity of iron in manganese, but although the longest iron lines are not there, some of the faintest basic ones are. This I hold to be the explanation of the apparent confusion in which we are landed on the supposition that the elements are elementary.

Application of these Considerations to Known Compounds.

Now to apply this reasoning to the dissociation of a known compound body into its elements.—

A compound body, such as a salt of calcium, has as definite a spectrum as a simple one; but while the spectrum of the metal itself consists of lines, the number and thickness of some of which increase with increased quantity, the spectrum of the compound consists in the main of channelled spaces and bands, which increase in like manner.

In short, the molecules of a simple body and a compound one are affected in the same manner by quantity in so far as their spectra are concerned; *in other words, both spectra have their long and short lines*, the lines in the spectrum of the element being represented by bands or fluted lines in the spectrum of the compound; and in each case the greatest simplicity of the spectrum depends upon the smallest quantity, and the greatest complexity (a continuous spectrum) upon the greatest.

The heat required to act upon such a compound as a salt of calcium so as to render its spectrum visible, dissociates the compound according to its volatility; the number of true metallic lines which thus appear is a measure of the quantity of the metal resulting from the dissociation, and as the metal lines increase in number, the compound bands thin out.

I have shown in previous papers how we have been led to the conclusion that binary compounds have spectra of their own, and how this idea has been established by considerations having for a basis the observations of the long and short lines.

It is absolutely similar observations and similar reasoning which I have to bring forward in discussing the compound nature of the chemical elements themselves.

In a paper communicated to the Royal Society in 1874, referring, among other matters, to the reversal of some lines in the solar spectrum, I remarked,*—

"It is obvious that greater attention will have to be given to the precise *character* as well as to the position of each of the Fraunhofer lines, in the thickness of which I have already observed several anomalies. I may refer more particularly at present to the two H lines 3933 and 3968 belonging to calcium, which are much thicker in all photographs of the solar spectrum [I might have added that they were by far the thickest lines in the solar spectrum] than the largest calcium line of this region (4226·3), this latter being invariably thicker than the H lines in all photographs of the calcium spectrum, and remaining, moreover, visible in the spectrum of substances containing calcium in such small quantities as not to show any traces of the H lines.

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* Phil. Trans., vol. clxiv, part 2, p. 807.

"How far this and similar variations between photographic records and the solar spectrum are due to causes incident to the photographic record itself, or to variations in the intensities of the various molecular vibrations under solar and terrestial conditions, are questions which up to the present time I have been unable to discuss."

An Objection Discussed.

I was careful at the very commencement of this paper to point out that the conclusions I have advanced are based upon the analogies furnished by those bodies which, by common consent and beyond cavil and discussion are compound bodies. Indeed, had I not been careful to urge this point the remark might have been made that the various changes in the spectra to which I shall draw attention are not the results of successive dissociations, but are effects due to putting the same mass into different kinds of vibration or of producing the vibration in different ways. Thus the many high notes, both true and false, which can be produced out of a bell with or without its fundamental one, might have been put forward as analogous with those spectral lines which are produced at different degrees of temperature with or without the line, due to each substance when vibrating visibly with the lowest temperature. To this argument, however, if it were brought forward, the reply would be that it proves too much. If it demonstrates that the *h* hydrogen line in the sun is produced by the same molecular grouping of hydrogen as that which gives us two green lines only when the weakest possible spark is taken in hydrogen inclosed in a large glass globe, it also proves that calcium is identical with its salts. For we can get the spectrum of any of the salts alone without its common base, calcium, as we can get the green lines of hydrogen without the red one.

I submit, therefore, that the argument founded on the overnotes of a sounding body, such as a bell, cannot be urged by any one who believes in the existence of any compound bodies at all, because there is no spectroscopic break between acknowledged compounds and the supposed elementary bodies. The spectroscopic differences between calcium itself at different temperatures is, as I shall show, as great as when we pass from known compounds of calcium to calcium itself. There is a perfect continuity of phenomena from one end of the scale of temperature to the other.

Inquiry into the Probable Arrangement of the Basic Molecules.

As the results obtained from the above considerations seemed to be so far satisfactory, inasmuch as they at once furnished an explanation of the *basic lines* actually observed, the inquiry was thought worthy of being carried to a further stage.

The next point I considered was to obtain a clear mental view of the manner in which, on the principle of evolution, various bases might now be formed, and then become basic themselves.

It did not seem unnatural that the bases should increase their complexity by a process of continual multiplication, the factor being 1, 2, or even 3, if conditions were available under which the temperature of their environment should decrease, as we imagined it to do from the furnace A down to furnace D. This would bring about a condition of molecular complexity in which the proportion of the molecular weight of a substance so produced in a combination with another substance would go on continually increasing.

Another method of increasing molecular complexity would be represented by the addition of molecules of different origins. Representing the first method by A+A, we could represent the second by A+B. A variation of the last process would consist in a still further complexity being brought about by the addition of another molecule of B, so that instead of $(A+B)_2$ merely, we should have $A+B_2$.

Of these three processes the first one seemed that which it was possible to attack under the best conditions, because the consideration of impurities was eliminated; the prior work has left no doubt upon the mind about such and such lines being due to calcium, others to iron, and so forth. The inquiry took this form, granting that these lines are special to such and such a substance, does each become basic in turn as the temperature is changed?

I therefore began the inquiry by reviewing the evidence concerning calcium and seeing if hydrogen, iron and lithium behaved in the same way.

Application of the above Views to Iron, Lithium, and Hydrogen.

Calcium.—It was in a communication to the Royal Society made some time ago (Proceedings, vol. xxii, p. 380, 1874), that I first referred to the possibility that the well-known line-spectra of the elementary bodies might not result from the vibration of similar molecules. I was led to make the remark in consequence of the differences to which I have already drawn attention in the spectra of certain elements as observed in the spectrum of the sun and in those obtained with the ordinary instrumental appliances.

Later (Proc. Roy. Soc., No. 168, 1876) I produced evidence that the molecular grouping of calcium which, with a small induction-coil and small jar, gives a spectrum with its chief line in the blue, is nearly broken up in the sun, and quite broken up in the discharge from a large coil and jar, into another or others with lines in the violet.

I said "another," or "others," because I was not then able to determine whether the last named lines proceeded from the same or different molecules; and I added that it was possible we might have to wait for photographs of the spectra of the brighter stars before this point could be determined.

I also remarked that this result enabled us to fix with very considerable accuracy the electric dissociating conditions which are equivalent to that degree of dissociation at present at work in the sun.

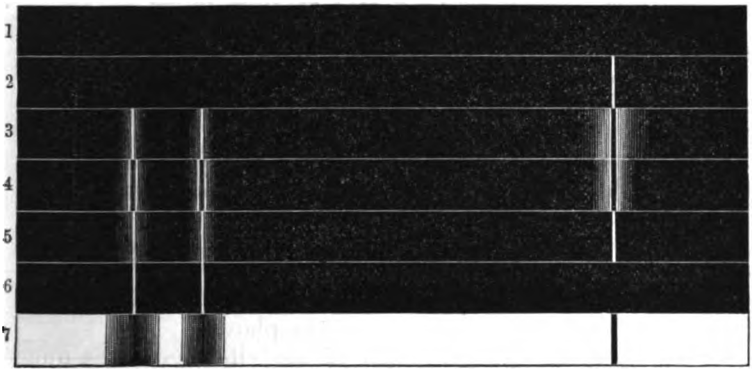


FIG. 3.—The blue end of the spectrum of calcium under different conditions. 1. Calcium is combined with chlorine ($CaCl_2$). When the temperature is low, the compound molecule vibrates as a whole, the spectrum is at the red end, and no lines of calcium are seen. 2. The line of the metal seen when the compound molecule is dissociated to a slight extent with an induced current. 3. The spectrum of metallic calcium in the electric arc with a small number of cells. 4. The same when the number of cells is increased. 5. The spectrum when a coil and small jar are employed. 6. The spectrum when a large coil and large jar are used. 7. The absorption of the calcium vapor in the Sun.

In fig. 3 I have collected several spectra copied from photographs in order that the line of argument may be grasped.

First we see what happens to the non-dissociated and the dissociated chloride. Next we have the lines with a weak voltaic arc, the single line to the right (W. L. 4226·3) is much thicker than the two lines (W. L. 3933 and 3968) to the left, and reverses itself.

We have next calcium exposed to a current of higher tension. It will be seen that here the three lines are almost equally thick, and all reverse themselves.

Now it will be recollected, that in the case of known compounds the band structure of the true compounds is reduced as dissociation works its way, and the spectrum of each constituent element makes its appearance. If in 3 we take the wide line as representing the banded spectrum of the compound, and the thinner ones as representing the longest elemental lines making their appearance as the result of partial dissociation, we have, by hypothesis, an element behaving like a compound.

If the hypothesis be true, we ought to be able not only to obtain, with lower temperatures, a still greater preponderance of the single line, *as we do;* but with higher temperatures, a still greater preponderance of the double ones, *as we do.*

I tested this in the following manner: Employing photography, because the visibility of the more refrangible lines is small, and because a permanent record of an experiment, free as it must be from all bias, is a very precious thing.

Induced currents of electricity were employed in order that all the photographic results might be comparable.

To represent the lowest temperature I used a small induction coil and a Leyden jar only just large enough to secure the requsite amount of photographic effect. To represent the highest, I used the largest coil and jar at my disposal. The spark was then taken between two aluminium electrodes, the lower one cup-shaped, and charged with a salt of calcium.

In the figure I give exact copies of the results obtained. It will be seen that with the lowest temperature only the single line (2) and with the highest temperature only the two more refrangible lines (6) are recorded on the plate.

This proved that the intensity of the vibrations was quite changed in the two experiments.

Perhaps it may not be superfluous here to state the reasons which induced me to search for further evidence in the stars.

It is abundantly clear that if the so-called elements, or more properly speaking their finest atoms—those that give us line spectra—are really compounds, the compounds must have been formed at a very high temperature. It is easy to imagine that there may be no superior limit to temperature, and therefore no superior limit beyond which such combinations are possible, because the atoms which have the power of combining together at these transcendental stages of heat do not exist as such, or rather they exist combined with other atoms, like or unlike, at all lower temperatures. Hence association will be a combination of more complex molecules as temperature is reduced, and of dissociation, therefore, with increased temperature there may be no end.

That is the first point.

The second is this:—

We are justified in supposing that our "calcium," once formed, is a distinct entity, whether it be an element or not, and therefore, by working at it alone, we should never know whether the temperature produces a single simpler form or more atomic condition of the same thing, or whether we actually break it up into X+Y, because neither X nor Y will ever vary

But if calcium be a product of a condition of relatively lower temperature, then in the stars, hot enough to enable its constituents to exist uncompounded, we may expect these constituents to vary in quantity; there may be more of X in one star and more of Y in another; and if this be so, then the H and K lines will vary in thickness, and the extremest limit of variation will be that we shall only have H representing, say X in one star, and only have K representing, say Y in another. Intermediately between these extreme conditions we may have cases in which, though both H and K are visible, H is thicker in some and K is thicker in others.

Professor Stokes was good enough to add largely to the value of my paper as it appeared in the *Proceedings*, by appending a note pointing out that "When a solid body such as a platinum wire, traversed by a voltaic current, is heated to incandescence, we know that as the temperature increases not only does the radiation of each particular refrangibility absolutely increase, but the proportion of the radiations of the different refrangibilities is changed, the proportion of the higher to the lower increasing with the temperature. It would be in accordance with analogy to suppose that as a rule the same would take place in an incandescent surface, though in this case the spectrum would be discontinuous instead of continuous. Thus if A, B, C, D, E denote conspicuous bright lines of increasing refrangibility, in the spectrum of the vapor, it might very well be at that a comparatively low temperature A should be the brightest and the most persistent; at a higher temperature, while all were brighter than before, the relative brightness might be changed, and C might be the brightest and the most persistent, and at a still higher temperature E."

On these grounds Professor Stokes, while he regarded the facts I mentioned as evidence of the high temperature of the sun, did not look upon them as *conclusive* evidence of the dissociation of the molecule of calcium.

Since that paper was sent in, however, the appeal to the stars to which I referred in it has been made, and made with the most admirable results, by Dr. Huggins.

The result of that appeal is that the line which, according to Professor Stokes' view, should have prevailed over all others, as Sirius is acknowledged to be a hotter star than our sun, is that, if it exists at all in the spectrum, it is so faint that it was not recognized by Dr. Huggins in the first instance.

In Sirius, indeed, the H line due to one molecular grouping of calcium is as thick as are the hydrogen lines as mapped by Secchi, while the K line, due to another molecular grouping, which is equally thick in the spectrum of the sun, has not yet made its appearance.

In the sun, where it is as thick as H, the hydrogen lines have vastly thinned.

While this paper has been in preparation, Dr. Huggins has been good enough to communicate to me the results of his most important observations, and I have also had an opportunity of inspecting several of the photographs which he has recently taken. The result of the recent work has been to show that H and *h* are of about the same breadth in Sirius. In *a* Aquilæ while the relation of H to *h* is not greatly changed, a distinct approach to the solar condition is observed, K being now unmistakably present, although its breadth is small as compared with that of H. I must express my obligations to Dr. Huggins for granting me permission to enrich my paper by reference to these unpublished observations. His letter, which I have permission to quote, is as follows:—

"It may be gratifying to you to learn that in a photograph I have recently taken of the spectrum of *a* Aquilæ there is a line corresponding to the more refrangible of the solar H lines [that is K], but about half the breadth of the line corresponding to the first H lines.

In the spectra of *a* Lyræ and Sirius the second line is absent."

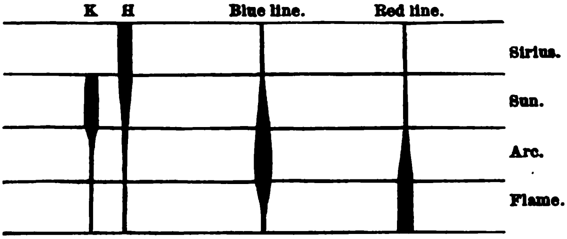


Fig. 4.—The Molecular Groupings of Calcium.

Professor Young's observations of the chromospheric line, to which I shall afterward refer, give important evidence regarding the presence of calcium in the chromosphere of the sun. He finds that the H and K lines of calcium are strongly reversed in every important spot, and that in solar storms H has been observed injected into the chromosphere seventy-five times, and K fifty times, while the blue line at W. L. 4226·3, the all-important line at the arc-temperature, was only injected thrice.

Further, in the eclipse observed in Siam in 1875, the H and K lines left the strongest record in the spectrum of the chromosphere, while the line near G in a photographic region of much greater intensity was not recorded at all. In the American eclipse of the present year the H and K lines of calcium were distinctly visible at the base of the corona, in which for the first time the observer could scarcely trace the existence of any hydrogen.

To sum up, then, the facts regarding calcium, we have first of all the H-line differentiated from the others by its almost solitary existence in Sirius. We have the K-line differentiated from the rest by its birth, so to speak, in *a* Aquilæ, and the thickness of its line in the sun, as compared to that in the arc. We have the blue line differentiated from H and K by its thinness in the solar spectrum while they are thick, and by its thickness in the arc while they are thin. We have it again differentiated from them by its absence in solar storms in which they are almost universally seen, and finally, by its absence during eclipses, while the H and K lines have been the brightest seen or photographed. Last stage of all, we have calcium, distinguished from its salts by the fact that the blue line is only visible when a high temperature is employed, each salt having a definite spectrum of its own, in which none of the lines to which I have drawn attention appear, so long as the temperature is kept below a certain point.

Iron.

With regard to the iron spectrum I shall limit my remarks to that portion of it visible on my photographic plates between H and G. It may be described as a very complicated spectrum so far as the number of lines is concerned in comparison with such bodies as sodium and potassium, lead, thallium, and the like, but unlike them again it contains no one line which is clearly and unmistakably reversed on all occasions. Compared, however, with the spectrum of such bodies as cerium and uranium the spectrum is simplicity itself.

Now among these lines are two triplets, two sets of three lines each, giving us beautiful examples of those repetitions of structure in the spectrum which we meet with in the spectra of almost all bodies, some of which have already been pointed out by Mascart, Cornu, and myself. Now the facts indicate that these two triplets are not due to the vibration of the same molecular grouping which gives rise to most of the other lines. They are as follows: In many photographs in which iron has been compared with other bodies, and in others again in which iron has been photographed as existing in different degrees of impurity in other bodies, these triplets have been seen almost alone, and the relative intensity of them, as compared with the few remaining lines, is greatly changed. In this these photographs resemble one I took three years ago, in which a large coil and jar were employed instead of the arc, which necessitated an exposure of an hour instead of two minutes. In this the triplet near G is very marked, the two adjacent lines more refrangible near it, which are seen nearly as strong as the triplet itself, in some of the arc photographs I possess, are only very faintly visible, while dimmer still are seen the lines of the triplet between H and *h*.

There is another series of facts in another line of work. In solar storms, as is well known, the iron lines sometimes make their appearance in the chromosphere. Now, if we were dealing here with one molecular grouping, we should expect the lines to make their appearance in the order of their lengths, and we should expect the shortest lines to occur less frequently than the longest ones. Now, precisely the opposite is the fact. One of the most valuable contributions to solar physics that we possess is the memoir in which Professor C. A. Young records his observation of the chromospheric lines, made on behalf of the United States Government, at Shumar, in the Rocky Mountains. The glorious climate and pure air of this region, to which I can personally testify, enabled him to record phenomena which it is hopeless to expect to see under less favorable conditions. Among these were injections of iron vapor into the chromosphere, the record taking the form of the number of times any one line was seen during the whole period of observation.

Now two very faint and short lines close to the triplet near G were observed to be injected thirty times, while one of the lines of the triplet was only injected twice.

The question next arises, are the triplets produced by one molecular grouping or by two? This question I also think the facts help us to answer. I will first state by way of reminder that in the spark photograph the more refrangible triplet is barely visible, while the one near G is very strong. Now if one molecular grouping alone were in question this relative intensity would always be preserved however much the absolute intensity of the compound system might vary, but if it is a question of two molecules we might expect that in some of the regions open to our observation we should get evidence of cases in which the relative intensity is reserved or the two intensities are assimilated. What might happen does happen: the relative intensity of the two triplets in the spark photograph is grandly reversed in the spectrum of the sun. The lines barely visible in the spark photograph are among the most prominent in the solar spectrum, while the triplet which is strong in that photograph is represented by Fraunhofer lines not half so thick. Indeed, while the hypothesis that the iron lines in the region I have indicated are produced by the vibration of one molecule does not include all the facts, the hypothesis that the vibrations are produced by at least three distinct molecules includes all the phenomena in a most satisfactory manner.

Lithium.

Before the maps of the long and short lines of some of the chemical elements compared with the solar spectra, which were published in the Phil. Trans. for 1873, "Plate IX," were communicated to the Society, I very carefully tested the work of prior observers on the non-coincidence of the red and orange lines of that metal with the Fraunhofer lines, and found that neither of them were strongly if at all represented in the sun, and this remark also applies to a line in the blue at wavelength 4603.

The photographic lithium line, however, in the violet, has a strong representative among the Fraunhofer lines.

Applying, therefore, the previous method of stating the facts, the presence of this line in the sun differentiates it from all the others. For the differentiation of the red and yellow lines I need only refer to Bunsen's spectral analytical researches, which were translated in the Philosophical Magazine, December, 1875.

In Plate IV, two spectra of the lithium chloride are given, one of them showing the red line strong and the yellow one feeble, the other showing merely a trace of the red line, while the intensity of the yellow one is much increased, and a line in the blue is indicated. Another notice of the blue line of lithium occurs in a discourse by Professor Tyndall, reprinted in the Chemical News, and a letter of Dr. Frankland's to Professor Tyndall, dated November 7, 1861. This letter is so important for my argument, that I reprint it entire from the Philosophical Magazine, vol. xxii, p. 472:—

"On throwing the spectrum of lithium on the screen yesterday, I was surprised to see a magnificent blue band. At first I thought the lithium chloride must be adulterated with strontium, but on testing it with Steinheil's apparatus it yielded normal results without any trace of a blue band. I am just now reading the report of your discourse in the Chemical News, and I find that you have noticed the same thing. Whence does this blue line arise? Does it really belong to the lithium, or are the cone points or ignited air guilty of its production? I find there blue bands with common salt, but they have neither the definiteness nor the brilliancy of the lithium band. When lithium wire burns in air it emits a somewhat crimson light; plunge it into oxygen, and the light changes to bluish white. This seems to indicate that a high temperature is necessary to bring out the blue ray."

POSTSCRIPT, Nov. 22, 1861.—I have just made some further experiments on the lithium spectrum, and they conclusively prove that the appearance of the blue line depends entirely on the temperature. The spectrum of lithium chloride, ignited in a Bunsen's burner flame, does not disclose the faintest trace of the blue line; replace the Bunsen's burner by a jet of hydrogen (the temperature of which is higher than that of the Bunsen's burner) and the blue line appears, faint, it is true, but sharp and quite unmistakable. If oxygen now be solely turned into the jet, the brilliancy of the blue line increases until the temperature of the flame rises high enough to fuse the platinum, and thus put an end to the experiment."

These observations of Professors Tyndall and Frankland differentiate this blue line from those which are observed at low temperatures. The line in the violet to which I have already referred, is again differentiated from all the rest by the fact that it is the only line in the spectrum of the sun which is strongly reversed, so far as our present knowledge extends. The various forms of lithium, therefore, may be shown in the following manner.

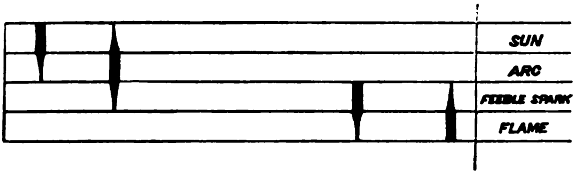


Fig. 5.—The Molecular Groupings of Lithium.

It is remarkable that in the case of this body which at relatively low temperature goes through its changes, its compounds are broken up at the temperature of the Bunsen burner. The spectrum, e. g. of the chloride, so far as I know, has never been seen.

Hydrogen.

All the phenomena of variability and inversion in the order of intensity presented to us in the case of calcium can be paralleled by reference to the knowledge already acquired regarding the spectrum of hydrogen.

Dr. Frankland and myself were working together on the subject in 1869. In that year (Proc., No. 112) we pointed out that the behavior of the *h* line was *hors ligne*, and that the whole spectrum could be reduced to one line, F.

"1. The Fraunhofer line on the solar spectrum, named *h* by Ångström, which is due to the absorption of hydrogen, is not visible in the tubes we employ with low battery and Leyden-jar power; it may be looked upon, therefore, as an indication of relatively high temperature. As the line in question has been reversed by one of us in the spectrum of the chromosphere, it follows that the chromosphere, when cool enough to absorb, is still of a relatively high temperature.

"2. Under certain conditions of temperature and pressure, the very complicated spectrum of hydrogen is reduced in our instrument *to one line in the green* corresponding to F in the solar spectrum."

As in the case of calcium also, solar observation affords us most precious knowledge. The *h* line was missing from the protuberances in 1875, as will be shown from the accompanying extract from the Report of the Eclipse Expedition of that year:—

"During the first part of the eclipse two strong protuberances close together are noticed; on the limb towards the end these are partially covered, while a series of protuberances came out at the other edge. The strongest of these protuberances are repeated three times, an effect of course of the prism, and we shall have to decide if possible the wave-lengths corresponding to the images. We expect *a priori* to find the hydrogen lines represented. We know three photographic hydrogen lines: F, a line near G, and *h*. F is just at the limit of the photographic part of the spectrum, and we find indeed images of protuberances towards the less refrangible part at the limit of photographic effect. For, as we shall show, a continuous spectrum in the lower parts of the corona has been recorded, and the extent of this continuous spectrum gives us an idea of the part of the spectrum in which each protuberance line is placed. We are justified in assuming, therefore, as a preliminary hypothesis, that the least refrangible line in the protuberance shown on the photograph is due to F, and we shall find support of this view in the other lines. In order to determine the position of the next line the dispersive power of the prism was investigated. The prism was placed on a goniometer table in minimum deviation for F, and the angular distance between F and the hydrogen line near G, i. e. Hγ, was found, as a mean of several measurements to be 3′. The goniometer was graduated to 15″, and owing to the small dispersive power, and therefore relatively great breadth of the slit, the measurement can only be regarded as a first approximation. Turning now again to our photographs, and calculating the angular distance between the first and second ring of protuberances, we find that distance to be 3′ 15″. We conclude, therefore, that this second ring is due to hydrogen. We, therefore, naturally looked for the third photographic hydrogen line, which is generally called *h*, but we found no protuberance on our photographs corresponding to that wave-length. Although this line is always weaker than Hγ, its absence on the photograph is rather surprising, if it be not due to the fact that the line is one which only comes out at a high temperature. This is rendered likely by the researches of Frankland and Lockyer (Proc. Roy. Soc., vol. xvii, p. 453).

"We now turn to the last and strongest series of protuberances shown on our photographs. The distance between this series and the one we have found reason for identifying with Hγ is very little greater than that between Hβ and Hγ. Assuming the distances equal, we conclude that the squares of the inverse wave-lengths of the three series are in arithmetical progression. This is true as a first approximation. We then calculated the wave-length of this unknown line, and found it to be approximately somewhat smaller than 3,957 tenth-meters. No great reliance can be placed, of course, on the number, but it appears that the line must be close to the end of the visible spectrum.

"In order to decide if possible what this line is due to, we endeavored to find out both by photography and fluorescence whether hydrogen possesses a line in that part of the spectrum. We have not at present come to any definite conclusion. In vacuum tubes prepared by Geissler containing hydrogen, a strong line more refrangible than H is seen, but these same tubes show between Hγ and Hδ, other lines known not to belong to hydrogen, and the origin of the ultra-violet line is therefore difficult to make out. We have taken the spark in hydrogen at atmospheric pressures, as impurities are easier to eliminate, but a continuous spectrum extends over the violet and part of the ultra-violet, and prevents any observation as to lines. We are going on with experiments to settle this point.

"Should it turn out that the line is not due to hydrogen, the question will arise what substance it is due to. It is a remarkable fact that the calculated wave-length comes very close to H. Young has found that these calcium lines are always reversed in the penumbra and immediate neighborhood of every important sun-spot, and calcium must therefore go up high into the chromosphere. We draw attention to this coincidence, but our photographs do not allow us to draw any certain conclusions.

"At any rate, it seems made out by our photographs that the photographic light of the protuberances is in great part due to an ultra-violet line which does not certainly belong to hydrogen. The protuberances as photographed by this ultra-violet ray seem to go up higher than the hydrogen protuberances, but this may be due to the relative greater length of the line."

In my remarks upon calcium I have already referred to the fact that the line which our observation led us to believe was due to calcium in 1875, was traced to that element in this year's eclipse. The observations also show the curious connection that, at the time when the hydrogen lines were most brilliant in the corona, the calcium lines were not detected; next, when the hydrogen lines, being still brilliant, the *h* line was not present (a condition of things which, in all probability, indicated a reduction of temperature). calcium began to make itself unmistakably visible; and finally, when the hydrogen lines are absent, they become striking objects in the spectrum of the corona.

To come back to *h*, then, I have shown that Dr. Frankland and myself, in 1869, found that it only made its appearance when a high tension was employed. We have seen that it was absent from among the hydrogen lines during the eclipse of 1875.

I have now to strengthen this evidence by the remark that it is always the shortest line of hydrogen in the chromosphere.

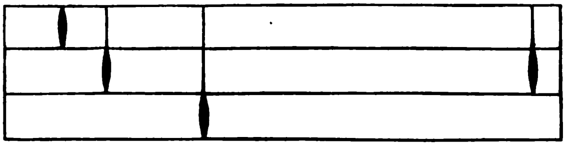
I now pass to another line of evidence.

I submit to the Society a photograph of the spectrum of indium, in which, as already recorded by Thalèn, the strongest line is one of the lines of hydrogen (*h*), the other line of hydrogen (near G) being absent. I have observed the C line in the spark produced by the passage of an induced current between indium poles in dry air.

As I am aware how almost impossible it is to render air perfectly dry, I made the following differential experiment. A glass tube with two platinum poles about half an inch apart was employed. Through this tube a slow current of air was driven after passing through a U tube one foot high, containing calcium chloride, and then through sulphuric acid in a Wolff's bottle. The spectrum of the spark passing between the platinum electrodes was then observed, a coil with five Grove cells and a medium sized jar being employed. Careful notes were made of the brilliancy and thickness of the hydrogen lines as compared with those of air. This done, a piece of metallic indium which was placed loose in the tube, was shaken so that one part of it rested against the base of one of the poles, and one of its ends at a distance of little less than half an inch from the base of the other pole. The spark then passed between the indium and the platinum. The red and blue lines of hydrogen were then observed both by my friend, Mr. G. W. Hemming, Q.C., and myself. Their brilliancy was most markedly increased. This unmistakable indication of the presence of hydrogen, or rather of that form of hydrogen which gives us the *h* line alone *associated into* that form which gives us the blue and red lines, showed us that in the photograph we were not dealing with a physical coincidence, but that in the arc this special form of hydrogen had really been present; that it had come from the indium, and that it had registered itself on the photographic plate, although ordinary hydrogen persistently refuses to do so. Although I was satisfied from former experiments that occluded hydrogen behaves in this respect like ordinary hydrogen, I begged my friend, Mr. W. C. Roberts, F.R.S., chemist to the Mint, to charge a piece of palladium with hydrogen for me. This he at once did, and I take this present opportunity to express my obligation to him. I exhibit to the Society a photograph of this palladium and of indium side by side. It will be seen that one form of hydrogen in indium has distinctly recorded itself on the plate, while that in palladium has not left a trace. I should add that the palladium was kept in a sealed tube till the moment of making the experiment, and that special precautions were taken to prevent the two pieces between which the arc was taken becoming unduly heated.

To sum up, then, the facts with regard to hydrogen: we have *h* differentiated from the other lines by its appearance alone in indium, by its absence during the eclipse in 1875, when the other lines were photographed by its existence as a short line only in the chromosphere of the sun, and by the fact that in the experiments of 1869 a very high temperature was needed to cause it to make its appearance.

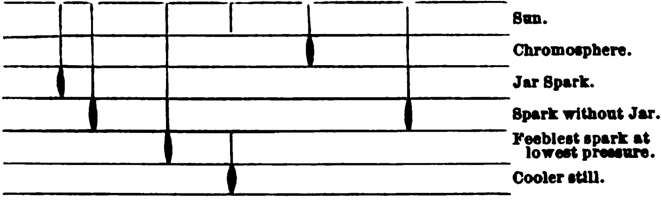
Fig. 6.



With regard to the isolation of the F line I have already referred to other experiments in 1869, in which Dr. Frankland and myself got it alone. I exhibit to the Society a globe containing hydrogen which gives us the F line without either the red or the blue one.

The accompanying drawing (Fig. 6) shows how these lines are integrated in the spectra of the sun.

Fig. 7.



I have other evidence which leads to the conclusion that the substance which gives us the non-reversed line in the chromosphere and the line 1474 of Kirchoff's scale, termed the coronal line, are really other forms of hydrogen. One of these is more simple than that which gives us *h* alone, the other more complex than that which gives us F alone. The evidence on this point is of such extreme importance to solar physics and throws so much light on star structure generally, that I shall reserve it for a special communication.

In the meantime I content myself by giving a diagram (Fig. 7) in which I have arranged the various groupings of hydrogen as they appear to exist, from the regions of highest to those of lowest temperature in our central luminary.

Summation of the above Series of Facts.

I submit that the facts above recorded are easily grouped together, and a perfect continuity of phenomena established on the hypothesis of successive dissociations analogous to those observed in the cases of undoubted compounds.

The other Branches of the Inquiry.

When we pass to the other possible evolutionary processes to which I have before referred, and which I hope to discuss on a future occasion, the inquiry becomes much more complicated by the extreme difficulty of obtaining pure specimens to work with, although I should remark that in the working hypothesis now under discussion, the cause of the constant occurrence of the same substance as an impurity in the same connection is not far to seek. I take this opportunity of expressing my obligations to many friends who have put themselves to great trouble in obtaining specimens of pure chemicals for me during the whole continuance of my researches. Among these I must mention Dr. Russell, who has given me many specimens prepared by the lamented Matthiessen, as well as some of cobalt and nickel prepared by himself; Prof. Roscoe, who has supplied me with vanadium and cæsium alum; Mr. Crookes, who has always responded to my call for thallium; Mr. Roberts, chemist to the Mint, who has supplied me with portions of the gold and silver trial plates and some pieces of palladium; Dr. Hugo Müller, who has furnished me with a large supply of electrolitically-deposited copper; Mr. Holtzman, who has provided me with cerium, lanthanum, and didymium prepared by himself; Mr. George Matthay, of the well-known metallurgical firm of Johnson and Matthay, who has provided me magnesium and aluminium of marvellous purity; while to Mr. Valentin, Mr. Mellor, of Salford, and other friends, my thanks are due for other substances.

I have already pointed out that a large portion of the work done in the last four years has consisted in the elimination of the effects of impurities. I am therefore aware of the great necessity for caution in the spectroscopic examination of various substances. There is, however, a number of bodies which permit of the inquiry into their simple or complex nature being made in such a manner that the presence of impurities will be to a certain extent negligable. I have brought this subject before the Royal Society at its present stage, in the hope that possibly others may be induced to aid inquiry in a region in which the work of one individual is as a drop in the ocean. If there is anything in what I have said, the spectra of all the elementary substances will require to be re-mapped and re-mapped from a new standpoint; further, the arc must replace the spark, and photography must replace the eye. A glance at the red end of the spectrum of almost any substance incandescent in a voltaic arc in a spectroscope of large dispersion, and a glance at the maps prepared by such eminent observers as Huggins and Thalen, who have used the coil, will give an idea of the mass of facts which have yet to be recorded and reduced before much further progress can be made.

In conclusion I would state that only a small part of the work to which I have drawn attention is my own. In some cases I have merely, as it were, codified the work done by other observers in other countries. With reference to that done in my own laboratory, I may here repeat what I have said before on other occasions, that it is largely due to the skill, patience, and untiring zeal of those who have assisted me. The burthen of the final reduction, to which I have before referred, has fallen to Mr. Miller, my present assistant; while the mapping of the positions and intensities of the lines was done by Messrs. Friswell, Meldola, Ord, and Starling, who have successively filled that post.

I have to thank Corporal Ewings, R.E., for preparing the various diagrams which I have submitted to the notice of this Society.

ART. XII.—*On the Velocity of very Loud Sounds;* by WILLIAM W. JACQUES, Fellow of the Johns Hopkins University.

IT is very well known that the velocity of a musical sound is, within very wide limits, sensibly independent of its intensity and of its pitch. The experimental proof of this is that a piece of music, played by a military band at a considerable distance, comes to the ear of the observer with its harmony entirely undisturbed.

A consideration of the theory of the propagation of a musical sound too, shows that for sounds such as we ordinarily hear, in which the change of density from the rarified to the condensed portion of the wave is small compared with the density of the undisturbed air, the velocity should be independent both of the intensity and the pitch.

When, however, we come to the consideration of a loud and sharp shock or explosion, in which the disturbances are very violent and abrupt, we cannot be at all sure that the changes of density are negligibly small, and hence that the velocity of sound for such cases would be a constant.

So little is known of the conditions in the case of the formation and propagation of sound from a center of explosion, and the mathematical considerations of such conditions as we may presume are so difficult, that we must look almost entirely to experiment for our knowledge of the propagation of very loud sounds. But our experimental evidence on this point is very limited. Nearly all of the experiments that have been made upon the velocity of sound have been made with a cannon and have not agreed remarkably well with each other; nor have the thermodynamic quantities calculated from them, on the supposition that the velocity is identical with that of a musical sound, agreed very well with the values of the same quantities determined by other methods. But we cannot say whether these errors are due to the character of the sound or to other causes.

The very short interval between the flash and the report of a stroke of lightning, even when it takes place at a considerable distance, has been instanced* as a proof of the greater velocity of very loud sounds, but, so far as the writer is aware, this has not yet been reduced to experiment.

The experiments of Regnault † in water pipes showed that the velocity of a pistol report became slightly less each time that it was reflected along the pipe, but the change was very small and its cause is doubtful.

The following paper contains an account of some automatic measurements of the velocity of sound in the immediate vicinity of a cannon. The results show that the velocity near a cannon is considerably different from that at a distance and point out a considerable error that has been introduced into the most important measurement of this quantity.

The experiments were made at the United States Arsenal in Watertown, Mass.

The method used was an automatic measurement of the velocity at different distances, varying from ten to one hundred and ten feet, from the mouth of the cannon, by means of a series of membranes‡ electrically connected with a chronograph.

In the midst of a large level field was placed a six-pound brass field piece. In the rear of this, at distances of 10, 30, 50,

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* Earnshaw, Phil. Mag., 1860. † Regnault's Memoirs.

‡ Regnault used membranes, though unlike these, in his water-pipe experiments.

70, 90 and 110 feet from the mouth of the cannon, were placed the membranes, elevated about three feet above the ground. These membranes consisted each of a hoop nine inches in diameter over which was stretched a sheet of thin rubber. To the center of the membrane, and on the side toward the cannon, was attached a very small shelf of polished brass. Upon this rested one end of a delicate steel spring, the other end being fixed to an independent support.

The wire that brought the current of electricity from the chronograph house was connected with the spring, and from the shelf a second wire returned to the chronograph. When the spring rested upon the shelf the circuit was closed. The passage of the sound wave, however, would move the membrane and break the circuit, causing a register on the chronograph. When the spring fell it rested upon a contact point from which a wire ran to the next membrane of the series, so that the circuit, immediately after being broken at the first membrane, was made again through the second, before the sound wave reached it. In this way the current could be transferred to all the membranes of the series and the successive breakings and makings of contact, as the sound wave passed each one, could be registered on a chronograph placed at a distance.

The chronograph used was of the Schultz form and consisted essentially of a rapidly and uniformly revolving cylinder of silver covered with lamp black, which was made one pole of the secondary coil of an inductorium, the primary coil of which was in circuit with the membranes. The other pole of the secondary coil was a fine metal point brought very near to the surface of the cylinder. When the primary circuit was broken or completed at the membranes, a spark passed between the metal point and the cylinder and made a fine dot in the lamp black. By the side of the point was an electrical tuning-fork which traced a sinuous curve of times on the lamp-blacked surface of the cylinder. The time could thus be measured to ·00001 of a second. All that was necessary then for the experiment was to choose a moment when the air was as nearly as possible at rest and then, the membranes being in order, to start the chronograph and fire the gun. The distances between the membranes were then accurately measured, the times of passage between successive membranes determined from the chronograph and the temperatures read off from thermometers placed at each membrane.

The experiment was many times repeated with the membranes interchanged, with different velocities and parts of the chronograph cylinder and with other precautions to prevent possible errors, but always with the same result. It was found that immediately in the rear of the cannon the velocity of sound was less than at a distance, but that going further and further from the cannon, *the velocity of sound rose to a maximum considerably above the ordinary velocity and then fell gradually to about the velocity usually received.*

In order to determine whether the first low velocities were due, as was supposed, to the retarding influence of the bodily motion of the air around the cannon, it was pointed at right angles to its first position, when it was found that the maximum velocity came nearer to the cannon. Had the cannon been turned in the direction of the line of membranes the retardation would probably have become an acceleration. The experiment was, however, of course impracticable. That this apparent retardation was not due to the difference in time of action of the membranes, due to a variation of the force of the wave, is evident both from the very slight force required in either case and from the fact that the variation noticed is in the wrong direction.

The charge of powder was considerably varied and the heaviest charges, of course, caused the greatest deviation from the ordinary velocity.

The successive series of experiments, owing to differences in the charge and in the loading, gave different values of the velocity at any one place, but the facts above stated always remained the same.

Accordingly each series represents the condition of things better than the mean of several, and I have here given a table of three of the best series.

The first column represents the distance from the mouth of the cannon; the second the values of the corresponding velocities in the rear of the cannon, when the charge was one and a half pounds; the third when the charge was reduced to half a pound, and the last when the cannon was pointed at right angles to the line of membranes.

	Velocities reduced to 0° C.		
	Rear of cannon.		**Side of cannon.**
Interval.	**1½ lbs.**	**½ lb.**	
10– 30 feet.	1076 feet.	....	....
30– 50	1187	1032	1067
50– 70	1240	1091	1162
70– 90	1267	1120	1201
90–110	1262	1114	1188

The conclusions that we may draw from these experiments are: 1. That the velocity of sound is a function of its intensity. 2. That experiments upon the velocity of sound in which a cannon is used contain an error, probably due to the bodily motion of the air near the cannon. Evidently a musical sound of low intensity must be used for a correct determination of the velocity of sound.

ART. XIII.—*Has Lake Winnipeg discharged through the Minnesota within the last two hundred years?* by J. E. TODD.

AFTER reading General Warren's article in the December number of the Journal, I casually took up a copy of Stansbury's Report on Salt Lake. On page 152 I found a curious account of Baron La Hontan's Expedition up the "Long River" in 1689. The Baron states that he passed down the Wisconsin to the Mississippi, which he ascended nine days, when he "entered the mouth of the Long River, which looks like a lake full of bulrushes," up which he sailed for six weeks, but was prevented by the advance of the season from reaching its source. He learned from the natives, however, considerable about its upper course, which he incorporated in his map.

Captain Stansbury gives a map drawn in 1710 by John Senex, F.R.S., on which the discoveries of La Hontan are given. This represents the "Long River" as being like a long lake toward its source, and flowing nearly due east through 25° of longitude. Another curious point, it is represented as having a continuous water connection through the "Moingona" River with the Mississippi, at a point far south of its proper mouth, where La Hontan entered it.

La Hontan describes it as "all along very slack and easy, abating about three leagues," and the channel unusually straight. "Its banks," he says, "have a dismal prospect, and the water itself has an ugly taste; but then its usefulness atones for such inconveniences, for 'tis navigable with the greatest ease, and will bear barques of fifty tons."

That the "Long River" *may* have been the ancient Minnesota seems indicated, therefore, by their corresponding in position of their mouths, their similarity in breadth of stream and slowness of current. Moreover, the "Moingona" would then correspond to the Blue Earth and Des Moines, whose sources were formerly connected by "Union Slough," as shown by Dr. C. A. White, in his report on the Geology of Iowa.

The curious *eastward* direction of the Long River may possibly be explained partly by the strong eastward declination of the magnetic needle at that time, and partly by the strong desire of the Baron to find a way across the continent. Preconceived notions seem to have influenced him in several other of his statements and conclusions, but perhaps not more so than was customary in those days.

Tabor, Iowa, Dec., 1878.

ART. XIV.—*On the Results of the Spectroscopic Observation of the Solar Eclipse of July 29th*, 1878;[*] by GEORGE F. BARKER.

To Professor Henry Draper, M.D., Director of the Draper Eclipse Expedition:—

Dear Sir: I beg leave to submit to you herewith my Report on the spectroscopic observations made, and on the results obtained at Rawlins, Wyoming Territory, during the solar eclipse of July 29th, 1878, that portion of the work having been allotted to me by yourself in the organization of the expedition.

The instruments and apparatus used in the observations were loaned for the purpose from the physical cabinet of the University of Pennsylvania. They consisted (1) of an equatorially mounted achromatic telescope of four inches aperture made by Jones of London, (2) a direct-vision astronomical spectroscope by Merz of Munich, (3) a second direct-vision spectroscope by Hoffmann of Paris, (4) and a pocket spectroscope by George Wale & Co. Beside this spectroscopic outfit, a second four-inch achromatic telescope by Dollond was taken for use with the tasimeter by Dr. Edison, and a Savart, a Senarmont, and an Arago polariscope, for determining the polarization of the corona. The Merz spectroscope above mentioned is described in the Philosophical Magazine, IV, xli, Feb. 1871. It is provided with two compound direct-vision prisms, of which one or both can be used at pleasure, each consisting of five single prisms, two of flint glass with a refracting angle of 84°, and three of crown; one of these having a refracting angle of 84°, the others of 87°. The dispersive power of each of these compound prisms is about equal to that of two equilateral prisms of flint glass. The instrument has a collimating and an observing telescope, each furnished with an object glass two-thirds of an inch in aperture and four inches in focal length. The prism-tube is attached to the collimator by two centers, giving it a lateral motion about a line passing through these centers, which constitutes an axis parallel to the slit. The observing telescope is similarly attached to the tube carrying the prism. These motions serve to alter the incidence of the rays upon the surface of the prism, and also to bring any special part of the spectrum into the middle of the field. The observing telescope is provided with a positive eye-piece of an equivalent focal length of one inch, and also with a needle micrometer, having an eye-piece of one-half inch focus. The graduations upon this micrometer are strongly cut, enabling the positions and the distances of the lines measured with it, to be easily read even in a faint light. The spectroscope was firmly attached to the draw tube of the equatorial telescope by means of an open frame made by Zentmayer, so that the position of the image with reference to the slit could be readily observed.

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[*] **Read by permission of Dr. Draper at the St. Louis meeting of the American Association for the Advancement of Science.**

The time from the 19th of July, the date of our arrival at Rawlins, until the 29th, was occupied in setting up the instruments, in getting them into adjustment, and in practice with them. It was found that with only one of the compound prisms of the Merz spectroscope, the slit being placed radially, it was easy to observe the lines C and F reversed in the chromosphere, and also the bright line D_3. On the morning of the day of the eclipse, the solar edge was examined for protuberances, in order to locate them in advance of totality. But a single one was noticed, this being on the southwestern edge of the sun. As the time of first contact approached, the spectroscope was removed and a paper screen was attached to the draw tube, an image of the sun being formed on this screen by means of the eye-piece; thus enabling the time of this contact to be approximately determined and the subsequent progress of the eclipse to be conveniently observed. No spots were seen under these circumstances, though this could hardly have been expected since the solar image was so small, scarcely three inches in diameter, unless the spots were of large size. As the time of second contact drew near, the spectroscope was replaced upon the equatorial. Since you deemed it of importance to pay special attention to the oxygen lines in the vicinity of G, the micrometer of this instrument was, at your suggestion, so adjusted that one of its needle points rested on the hydrogen line near G, and the other on the line known as *h*. After the last ray of sunlight had disappeared, I took a few seconds of the precious time to observe the eclipse with the naked eye. The moon appeared intensely black, surrounded by a pinkish halo, extending to about two-fifths of a lunar diameter from the limb, and occupying the entire circumference. At two points this halo was expanded into radial streamers, one of which had parallel sides with a deeply indented or swallow-tailed end, extending westward of the sun and apparently lying in the ecliptic; the other appeared single, was on the eastern edge, and was inclined twenty degrees or more to the north of the ecliptic. The former of these streamers was traced to a distance of about a lunar diameter from the edge, the latter to a somewhat less distance. No structure could be seen in the halo, but in the streamers traces of parallel rays appeared to be present. The amount of light emitted by the corona was a surprise to me. Preparations had been made for using artificial light for reading the circles, but this was found not to be at all necessary. The amount of light seemed to be nearly or quite equal to that given by the moon when ten days old. No protuberances were seen with the naked eye nor were any streamers observed, other than those already described. A glance at the eclipsed sun was then taken through the finder of the equatorial. The magnifying power being low, the corona presented much the same appearance as to the naked eye. But the streamers showed much more distinct evidences of a radiated structure and a pale rosy protuberance was observed on the southwestern edge of the dark disc. This was undoubtedly the same prominence which was observed previous to totality.

Turning my attention now to the spectroscope, upon the slit of which the coronal image had already been brought by means of the finder, the slit being placed radially, the first glance through the instrument showed me a bright but an absolutely continuous spectrum. The region under examination was of course that portion of the spectrum which had been placed before totality between the needle-points of the micrometer. Totally unprepared for so unexpected a result, I moved the observing telescope so as to bring the green portion of the spectrum into the field, expecting certainly to see 1474 K and by the appearance of this line to determine whether my instrument was out of adjustment; and if it was to adjust it again. But no bright line was there; the green region appeared as continuous as the blue. I then gradually closed the slit—which had been previously adjusted on the solar spectrum so that the line D appeared nebulous on its edges—thinking that I might in this way improve the definition; but with no better result; no bright lines could be seen. To my great surprise however, when the slit was thus narrowed, the region which was then under examination, that extending from *b* to G, appeared filled with dark lines on the brighter background, these dark lines being readily recognized from their general appearance as the solar lines of Fraunhofer. Still intent on getting bright lines, I opened the slit again gradually, moved the observing telescope over the entire length of the spectrum from red to violet, repeating the operation three times and varying the width of the slit from time to time in each region; but not a single bright line could be detected. I then requested you to come and take a glance through my spectroscope, as had been previously agreed; saying that although I could see dark lines and a continuous spectrum, I was unable to detect a single bright line and knew not what to make of it. You were then looking at the eclipse through your ingenious little telespectroscope of two inches aperture. You came to my instrument, looked at the spectrum, moved the observing telescope over its whole length and remarked that the results in my spectroscope agreed entirely with those in yours, and that the spectrum appeared in both absolutely continuous. My mind being thus relieved, I took my place again at the spectroscope, and this time, placing the slit tangential to the moon's limb, I moved the observing telescope from end to end of the spectrum, opening and closing the slit at intervals; but the spectrum appeared as continuous as before. Again the image was adjusted so that the slit was once more radial; and this time on still a different portion of the corona. On examining again the spectrum, no bright lines appeared, except once for an instant, when the slit passed over the small chromospheric prominence already noticed. Warned by Mrs. Draper's clear and distinct counting that the precious 165 seconds had two-thirds gone, I decided to devote the time still remaining to a more careful observation of the dark Fraunhofer lines. Now, for the first time, as I adjusted the width of the slit and its position on the corona with more care, I observed that these lines did not pass clear across the field, but were of a length corresponding to the width of the coronal image on the slit. At the base of the spectrum, which corresponded to the base of the corona, they appeared bright and sharp; certainly quite as much so as in the light of the moon similarly condensed; though the continuous spectrum which formed their background was relatively brighter than in moonlight. There was no difficulty in identifying them as Fraunhofer lines from their general appearance and position; but some of them could be identified beyond question. Such were *b* and F, which were especially distinct, and D, E and G which were considerably less so. They faded gradually out from the base of the spectrum upward, appearing to end where the continuous spectrum of the corona was limited above. While thus employed, a flash of sunlight told us that totality had ended and that the solar eclipse of 1878 was over.

In discussing the results of the spectroscopic observations which have now been detailed, I am, in the first place, quite at a loss to account for the fact that no bright lines were seen by me, notwithstanding the persistent efforts made to get them. The failure to observe them can be accounted for, as it would seem, only on the ground that with the dispersive power employed, the bright lines were too faint to be seen on the much brighter background of the continuous spectrum.

The lessons to be drawn from these spectroscopic observations appear to be few and simple. The absence of bright lines, or at least of any which were at all brilliant, proves clearly the absence in the solar coronal region of any considerable mass of incandescent gas or vapor, which shining by its own light would of course give a bright-line spectrum. The presence of

Fraunhofer lines in the coronal spectrum shows conclusively the presence of reflected sunlight in the light of the corona and goes to establish the theory, long ago suggested, that masses of meteoric matter raining down upon the solar surface from all directions reflected to us the light of the sun, and were, therefore, the essential cause of the coronal phenomena. And, finally, the fact of the increased brightness of the continuous spectrum, as compared with the intensity of the dark lines of Fraunhofer, goes to strengthen the probability that there is still other light in the corona which comes to us from the incandescent liquid or solid matter of these intensely heated meteoric masses. These conclusions, deduced very simply from my own spectroscopic results, agree completely, I am happy to find, with those drawn from your most excellent photographs, as well as from the ingenious heat-measurements of Dr. Edison and the polariscopic determinations of Dr. Morton.

In concluding this Report, you will permit me I am sure, to express the great gratification which the Draper Eclipse Expedition has continually afforded me. The delight at being able to witness a total eclipse of the sun, has been intensified by the complete success of all the attempts made to observe it, and by the most agreeable companionship during the trip. My obligation to you for the opportunity is as profound as my thanks to you for it are sincere and cordial.

Truly yours, GEORGE F. BARKER.

Philadelphia, August 10th, 1878.

ART. XV.—*On a mode of measuring the Velocity of Sound in Wood;* by MAGNUS C. IHLSENG, Ph.D.

[Read before the National Academy of Science, October, 1877.]

THE subject of this paper was suggested to me by Professor Rood, and the work carried out under his direction in the physical laboratory of Columbia College.

Since the study by Chladni of longitudinal vibration in rods, many researches upon this point have rendered them of great importance for the determination of the velocity of sound and the elasticity of solid bodies. The methods of measuring the velocity of sound in solids, which depended upon the perception by the ear of the unison of two notes were difficult in practice and gave imperfect results. Du Hamel* proposed to cause a pen attached to the rod to describe a wave line on a revolving glass plate, and thus to register vibrations; he did not carry the project into effect. Wertheim† in his excellent work employed a method of this kind, and connected with the rod a chronographic apparatus. He determined the transverse vibrations of the rod by simultaneously registering those of a tuning fork, and then superimposed the longitudinal vibrations of the rod upon its transverse, and ascertained from the corrugated wave line thus produced, the relation between the longitudinal and transverse vibrations.

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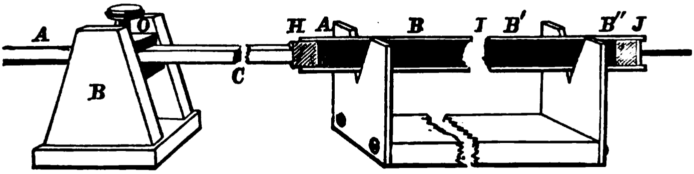
* Journal de Ecole Polytechnic Cohier, xxiii, 19.

† Pogg. Annalen, Ergänz., ii, 1.

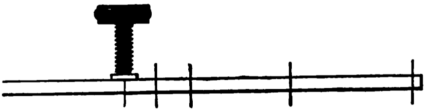
Kundt,* however, in 1866 contrived a method which is so well known as to need only a few words of description. A sounding rod is compelled to set into vibration a column of air enclosed in a glass tube, and in accordance with the laws of the organ pipes, the ratio of the length of the wave in the sounding rod to that of the wave of air in the glass tube, is obtained. Having corrected this for the temperature and the hygrometric state of the atmosphere it is possible to obtain a value for the velocity of propagation. During the past year, Kayser† employed Kundt's method for studying the ratio of the specific heat under a constant volume to the specific heat under a constant pressure.

1.



All of the above experiments were made upon metals. With the exception of MM. Wertheim and Chevandier's extended researches‡ upon the woods of the Vosga forests, I know of but very few determinations of the velocity of sound in wood. Having intended to measure the velocity of sound in some American woods, Kundt's method was first employed; the apparatus was similar to his but somewhat modified to suit the special circumstances. Fig. 1 shows the arrangement in perspective; B is the vise holding the rod, AC, clamped by a screw, O, acting on a plate of brass which presses the rod firmly upon its rest; the vise is screwed upon the table, which is fastened to the floor and braced to avoid shaking. The rod is rubbed by a resined woolen cloth along A, and being set into vibration,

2.



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* Pogg. Ann., cxxvii, 337. † Ibid., 1877, N. 10, p. 218.

‡ Comptes Rendus, xxiii, 663.

communicates it to the air in the glass tube, I, the dust figures then are formed at the nodes A, B, B′, B″, etc. The distances AB and B′ B″ are the semi-wave lengths of air corresponding to the note given by the rod. Although the length AB″ does not materially affect the length of the waves, it has been found best to make it equal to a multiple of the semi-wave lengths as then the figures are most definite. The glass tube was 1^{m}

TABLE I.

Name of wood.	No. rod.	Length.	Section.	Sp. Gr.
Cedar,	1	$1836·0^{mm}$	$14·25 \times 21·45^{mm}$	·432
“	2	1838·4	$14·15 \times 21·45$	·482
“	3	1838·75	$15·6 \times 20·45$	·465
“	4	1836·72	$14·3 \times 21·6$	·417
“	24	1650·0	$14·3 \times 21·1$	·478
White wood.	5	1876·92	$12·4 \times 26·35$	
“	6	1838·57	$11·77 \times 26·42$	·476
“	7	1834·0	$12·35 \times 26·85$	·443
“	8	1162·25	$12·38 \times 13·17$	
“	9	1162·55	$13·0 \times 13·14$	
“	10	1142·37	$12·28 \times 13·00$	·478
“	11	1164·94	$12·79 \times 13·23$	
“	12	1184·73	$12·94 \times 13·16$	
White pine,	13	1842·6	$17·86 \times 21·27$	·491
“ “	15	1841·9	$17·45 \times 23·05$	·432
Yellow “	23	1052·45	$12·17 \times 24·11$	·664
Hickory,	14	1550·5	$24·27 \times 12·95$	·922
White ash,	16	1836·5	$9·55 \times 19·65$	·544
“	17	1838·26	$9·55 \times 19·70$	·541
“	18	1809·7	$14·98 \times 17·6$	·593
White holly,	19	1378·5	$10·30 \times 10·91$	·562
Mahogany,	20	1349·1	$11·54 \times 11·52$	·540
Black Walnut,	21	1378·63	$10·82 \times 9·73$	·518
Cherry,	22	1560·1	$10·92 \times 11·49$	·693
Red oak,	25	1494·7	$12·35 \times 18·28$	·650
White oak,	26	1494·5	$12·68 \times 17·98$	·775

Velocities obtained by Kundt's method.

TABLE II.

Rods.	Number of observations.	Temperature.	Velocity.	Probable error.
No. 1	25	15°·5 C.	3906·3 M.	2·4 M.
“ 2	40	20·7	4027·6	8·08
“ 3	25	16·1	3966·4	4·62
“ 4	25	15·8	4071·68	9·90
“ 5	25	13·5	5164·6	2·58
“ 6	30	15·6	5129·9	12·29
“ 7	35	16·3	5249·3	2·6
“ 8	30	14·0	4912·31	4·3
“ 9	35	14·4	4739·63	4·3
“ 10	30	14·6	4712·53	2·4
“ 11	25	14·5	5309·4	7·9
“ 12	25	14·3	4845·17	3·4
“ 13	35	15·4	4783·15	2·5
“ 14	25	16·4	4110·07	2·1

long and 19^{mm} internal diameter; the cork H, inclusive of the two pins which held it to the rod, weighed 1·08 grams. With this apparatus the velocity of sound in the following woods was measured; cedar, white wood, yellow and white pine, hickory, white ash, holly, mahogany, black walnut, cherry and white oak.

The probable error is so small that it would seem to indicate either that the procedure is a very accurate one or that the error is constant and in the same direction.

But during the progress of these experiments, another method was devised whereby the rod registered its own vibrations. A blackened glass plate was drawn rapidly by in a horizontal direction by a falling weight, and matters were so arranged that a pen attached to the rod of wood wrote its vibration upon the plate, which simultaneously registered those of a tuning fork. The apparatus was capable of being leveled accurately, and it had connected with it an arrangement that enabled the observer to set it into action at any desired instant. The final result, of course, is that two parallel sets of curves are traced on the smoked glass. For the purpose of making the measurements it was necessary to compare the corresponding portions of the two curves, and two lines were drawn at right angles to them so as to include corresponding portions. This was effected by a little piece of apparatus especially contrived for the purpose. The number of waves registered were then counted with the aid of a compound microscope, which with its micrometer eye-piece was also used to measure the fractional parts of the waves. It was found possible with this arrangement to estimate, without any difficulty, the fiftieth part of a wave length. The following columns give ten readings of a single wave length, showing their agreement; the wave traced on the smoked glass, in this case, had an average length of $3{\cdot}56^{mm}$.

3·57	3·58
3·60	3·55
3·58	3·42
3·70	3·30
3·52	——
3·75	3·56

For determining the rate of the fork, the average of six determinations of 5·033 seconds each, by a chronograph, was taken as follows: $\frac{7701{\cdot}70}{6\times5{\cdot}033}=255{\cdot}04$.

The difference between this quantity and the number of vibrations stamped on the fork by Kœnig (256) was due to the fact that the fork was loaded by the wax and pointer.

TABLE III.

Rods.	Kundt's Method.		Graphic Method.		Difference.
	Velocity V.	Probable Error.	Velocity V'.	Probable Error.	
1	3849·28 M.	2·5 M.	3785·3 M.	5·1 M.	64·0 M.
2	4061·56	2·79	4024.3	5·62	37·26
3	3934·49	4·35	3870.5	5·51	64·0
6	4985·05	10·30	4896.7	9·56	88·35
7	5278·59	9·69	5225.3	3·37	53·29
13	4753·02	2·88	4715.3	5·45	37·72
23	4326·36	2·14	4265.6	7·88	60·76
24	3950·90	3·66	3871.2	6·64	79·7

The first determinations were on the comparison between the graphic and Kundt's method. To this end an experiment was made by combining both methods, thus: while the rod was urging the air column into synchronous action by means of the cork (Kundt's method), it simultaneously registered, with its pen, the rate of its vibration. The results obtained by this double method should, of course, agree, as both the motions originate from the same source. They were found, however, to differ as shown in the annexed table.

These values are averages of fifteen observations. A glance at this table shows that the air method gives results which are invariably higher than the graphic method, the difference between the numbers being much larger than the sum of the errors in the two cases. This may be due to the fact of Kundt using too large a coëfficient for the correction for moisture and temperature. The experiments having been conducted during the winter, the amount of moisture in the laboratory was a minimum. Thus, calculating the velocities on the supposition that the air was perfectly dry we obtain the following results which are still too high.

Rods.	Calculated Velocity.	Diff. from Graphic Method.
1	3838·04 M.	+ 53·74 M.
2	4038·42	+ 14·12
3	3922·53	+ 52·03
6	4966·34	+ 69·64
7	5263·93	+ 38·63
13	4728·40	+ 13·10
23	4311·05	+ 45·45
24	3939·01	+ 67·81

These comparisons show, it would seem, that the tendency of Kundt's methods, at least as used by me, was to give results which were somewhat higher than they should have been.

To the above it may be added that in these experiments on Kundt's method, the stopper J, figure 1, was placed at a node, thus making an air column in the tube which was in unison with the rod; the resistance to the rod's vibration was then small. But if we remove the stopper from the node and place it in the middle of a ventral segment, the resistance to vibration becomes a maximum, the rate of the rod is diminished and we have a lower number of vibrations actually executed and registered by the rod. Rod No. 23 was subjected to this test, its length being 1051·15^{mm}. While the rod was urging the air column into vibration, the stopper being at a node, the rate of vibration registered by the rod itself was 2029 per second. Removing the stopper to a ventral segment diminished the rate to 2009·2 vibrations. In the latter determination no satisfactory dust figures could be obtained.

Having thus compared these two methods, we now proceed to give the results obtained by the graphic method upon the several rods. The rods were clamped in the center and without any load except the inappreciable weight of the pen.

TABLE IV.

Velocity of sound in American woods: measured by the Graphic Method.

Names of Wood.	Length.	Sp. Gr.	Temp.	Velocity.	Probable Error.
Cedar, No. 1,	1836· mm	0·432	21·5 C.	3797·2 M.	3·56 M.
" 2,	1838·4	·482	20·9	4073·89	9·99
" 3,	1838·75	·465	28·4	3864·79	5·00
" 4,	1836·72	·417	---	4161·65	5·62
" 24,	1650·	·478	18·8	3915·47	5·89
White Wood, 6,	1838·57	·476	22·4	4927·30	7·43
" " 7,	1834·0	·443	19·8	5201·22	8·73
" " 10,	1142·37	·478	18·0	4650·60	3·90
" Pine, 13,	1842·6	·490	20·0	4713·36	6·63
" " 15,	1841·9	·432	20·0	4522·46	7·51
" Ash, 16,	1836·5	·544	27·0	4282·45	5·52
" " 17,	1838·26	·541	27·3	4261·51	5·88
" Holly, 19,	1378·5	·562	21·2	3657·41	4·95
Mahogany, 20,	1349·1	·540	20·0	4135·26	5·39
Black Walnut, 21,	1378·63	·518	19·1	4780·72	5·60
Cherry, 22,	1560·1	·693	18·0	4409·54	5·49
Yellow Pine, 23,	1052·45	·664	20·2	4274·48	5·60
Red Oak, 25,	1494·7	·650	25·0	4179·80	5·34
White Oak, 26,	1494·5	·775	25·0	4316·50	4·87

There were, however, certain difficulties to contend with which will now be briefly mentioned. I had not long been engaged upon this work, when I discovered a tendency to vertical transverse vibration in some of the rods, thus carrying the pointer off the plate. To meet this difficulty a kind of holder was contrived and covered with felt which, while only touching the rod lightly, held it in position. This damper was placed in various positions along the rod, and the corresponding rates of vibration measured. These values were tabulated for the several positions shown in fig. 2, which were as follows: E, as near the end as possible; D, 400^{mm} from E; C, 700^{mm}

from E; B, as near the center as the clamp would allow. The resulting values given in the following table are averages of fifteen observations.

TABLE V.

Showing the effect of the Damper.

Rods.	Damper at end.	At D.	At C.	At B.
No. 1,	3798·9 M.	3777·1 M.	3787·9 M.	3786·4 M.
" 2,	4063·7	4078·5	4062·7	4067·9
" 3,	3883·1	3872·0	3869·1	3865·0
" 6,	4876·8	4895·7	4840·7	4866·7
" 7,	5226·9	5205·0	5208·2	5213·7
" 13,	-----	4511·4	4517·6	4560·1
" 16,	4272·4	4244·4	4255·5	4259·3
" 17,	4259·1	4248·0	4256·0	4265·7

The results given in tables 2, 3 and 4 were obtained without the use of the damper.

It may be worth while to mention that some of the rods while vibrating longitudinally were capable of generating two notes, differing from each other by about a terz. These seemed to depend either upon some inherent condition of the wood or perhaps upon the relation between the two thicknesses and the length of the rod. A little practice is requisite for bringing out the lower note with sufficient power to cause it to be recognized and registered; it also required the exertion of a greater force for its production and always preceded the high note. I also found that the damper affected the high and low notes correspondingly. The velocities corresponding to the high note have already been given in tables 3, 4 and 5, while in table VI are the velocities deduced from the employment of the low note with rods 2 and 3 the damper being used.

TABLE VI.

Rods.	Damper at E.	At D.	At C.	At B.
No 2,	3637·6 M.	3663·2 M.	3663·6 M.	3704·7 M.
No. 3,	3643·87	3696·42	3677·12	3679·6

Subsequent investigation led me to the supposition of the coëxistence of transverse and longitudinal vibrations; the higher note being the normal note produced by longitudinal vibrations, the lower note being due to transverse motion.

In order to test this matter, the glass plate was caused by the falling weight to move in the direction of the length of the rod, and it was found in point of fact, possible in this manner to register its transverse vibration. The number of transverse vibrations obtained for the high note were very nearly equal to the number of the longitudinal vibrations. The same relation existed between the transverse and longitudinal vibrations producing the low note. This is evident from the table given below:

TABLE VII.

Number of longitudinal and transverse vibrations corresponding to the high note.

Rods	Number of longitudinal vibrations in a second — N.	Number of transverse vibrations in a second — N′.	Difference.
No. 2,	1107·97	1068·29	38·68
" 13,	1227·21	1246·05	18·84
" 19,	1326·59	1333·75	7·16
" 20,	1532·60	------	----
" 21,	1733·89	1717·43	16·46
" 22,	1413·26	1391·80	11·46

TABLE VIII.

Number of longitudinal and transverse vibrations corresponding to the low note.

Rod.	Longitudinal — n.	Transverse — n'.	Difference.
No. 2,	1009·29	978·58	30·71
" 13,	998·58	976·14	22·44
" 19,	1167·62	1162·54	5·08
" 20,	1204·31	------	----
" 21,	1332·04	1211·71	120·33
" 22,	1115·66	1119·24	3·58

The only difference in the appearance of the longitudinal and transverse tracings of either of the notes was in their amplitudes. The high note possessed a larger amplitude in longitudinal vibration, the low note in transverse. If now we compare Tables VII and VIII, we find no harmonic interval embraced in the ratios between N and n, or N′ and n', as is shown below; they however, in some cases approximate to a terz. Terz = 4 : 3.

TABLE IX.

Rod.	Ratio $\frac{n}{N}$.	Ratio $\frac{n'}{N'}$.	
No. 2,	1 : 0·9109	1 : 0·9161	secund = ·888.
" 13,	0·8137	0·7834	terz = ·8.
" 19,	0·8802	0·8701	secund = ·888.
" 20,	0·7858	-----	
" 21,	0·7682	0·7055	quart = ·75.
" 22,	0·7894	0·8041	terz ·8.

From the above experiments, we conclude; (1) That it is possible to measure the velocity of sound in rods with considerable accuracy by the graphic method; (2.) Kundt's method gives results which are slightly higher than those by the graphic method; (3.) The graphic method demonstrates the existence of transverse along with longitudinal vibration and gives their ratios.

Columbia College, Oct. 25th, 1877.

ART. XVI.—*The Relation of Secular Rock-disintegration to Lœss, Glacial Drift and Rock Basins*;* by RAPHAEL PUMPELLY.

THE recent volume of Baron Richthofen's great work on China and Central Asia, is, to a considerable extent, occupied with a description of the great lœss formation and of the processes to which it owes its origin.

This remarkable formation covers several hundred thousand square miles in northern China, and larger areas in the rest of Asia. It forms the soil also over an immense area in the western United States. Its thickness varies, in China up to 2000 feet, and to 150 and 200 feet in Europe and America.

Lœss is a calcareous loam. It is easily crushed in the hand to an almost impalpable powder, and yet its consistency is such that it will support itself for many years in vertical cliffs 200 feet high. A close examination shows that it is filled with tubular pores branching downward like rootlets, and that these tubes are lined with carbonate of lime. It is to these that it owes its consistency and its vertical internal structure. It is wholly unstratified, and often where erosion has cut into it, whether one foot or one hundred yards, the walls are absolutely vertical. Its vertical internal structure causes it to break off in any vertical plane but in no other. Hence when a cliff is undermined the lœss breaks off in immense vertical plates leaving again a perpendicular wall.

It is divided into beds varying in thickness from one foot to two or three hundred which thin out to nothing at the borders and are separated by parting planes. These planes are marked by angular debris near the mountains, and by elongated upright calcareous concretions elsewhere.

This remarkable combination of softness with great strength and stability of exposed surfaces is of inestimable value in a woodless country. In Asia thousands of villages are excavated in the most systematic manner at the base of cliffs of lœss. Doors and windows pierced through the natural front give light and air to suites of rooms which are separated by natural walls, and plastered with a cement made from the lœss concretions. These are the comfortable dwellings of many millions of Chinese farmers, and correspond to the ruder "dugouts" of Nebraska.

To the same qualities is due the fact that the lœss districts of China are exceedingly fertile plains, in each of which a rapidly progressing erosion has excavated the most labyrinthine valley systems, in which all the members, down to the smallest tributaries, are sunk with vertical walls to depths of from one hundred to several hundred feet. Even the wagon roads become, in time, depressed to a depth of fifty feet and more by the removal of the dust by wind.

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* **Read before the National Academy of Science, April 10th, 1878.**

There is one more peculiarity of the lœss—it not only is wholly unstratified, but it contains the remains of only land animals, and especially of land snails. Alexander Braun examined 211,968 specimens of shells from the lœss of the Rhine between Basel and Bonn, and found that all were land snails except only thirty-three individuals, consisting of *Limnœa Planorbis* and *Vitrina*, which came from three isolated points in the valley of the Rhine and Neckar.

The lœss, first well known in the valley of the Rhine and in France, was recognized later in other parts of Europe and in the Mississippi Valley. It was always looked upon as a subaqueous formation. Fourteen years ago I observed and afterward described some of the great lœss-basins along the boundaries between China and Central Asia. I was lead to the conclusion, chiefly from topographical reasons, that the lœss of these valleys had been deposited in a series of great lakes; and subsequent observers took the same view. But Richthofen, extending his fruitful journeyings over a wide area, found the lœss occupying the loftiest passes of northeastern China, over 8,000 feet above the sea, and he proves, in the most conclusive manner, that an aqueous origin is impossible. For the former theories of lœss formation which required inconceivable conditions and are full of contradictions, Richthofen substitutes an exceedingly simple and thoroughly consistent explanation. I hope I may be excused for giving it in brief terms:

Whenever, from any cause, the winds blowing toward an interior portion of a continent are drained of their moisture on the way, as by the elevation in their path of lofty condensing mountains, the region thus deprived of its rain-bringing clouds soon has its evaporation in excess of its rainfall. Its streams dry up; its soluble and insoluble products of disintegration are no longer carried to the ocean; the region becomes what Richthofen calls a central area, in contrast to peripheral regions which are drained directly into the ocean. The destruction of the vegetation lays bare the surface, and the products of disintegration are blown and sorted by the wind and washed by the occasional rains from the hills down into the valleys. This material is very nutritive and supports the grass of the steppes; the dust left by the winds and the hill-wash are arrested by the grass which they gradually bury while forming the soil for new growths. In this way, portions of the country become buried in their own and their neighbor's debris. Great thicknesses thus gradually accumulate undergoing a transformation into lœss by the rootlets and stems of the vegetation. I will remark here that Richthofen has made known the fact that the lœss is the most fertile of soils, and that the grain-regions of northern China which have been continuously cultivated for more than 4,000 years require practically no manure but that they are self-fertilizing. This he ascribes partly to the porosity of the material which causes it to absorb carbonic acid and ammonia in large amounts from the air; but more especially to the elevation of nutritive salts in the capillary tubes by diffusion whenever a rain establishes a moist communication between the surface and the saline water below the drainage level.

Thus, whenever climatal changes have restored more or less moisture to the atmosphere of a lœss district, we have in it the utmost fertility. The cold and elevated regions of northern China are the granary of the empire—and the seat of the present great famine.

Attention has been recently called by the German geologists to the great fertility of the European lœss, and Professor Hayden has emphasized the fact that the abundant productiveness of much of the West is due to the same soil.

Recognizing from personal observation the full identity of character of the lœss of northern China, Europe and the Missouri Valley, I am obliged to reject my own explanation of the origin of the Chinese deposits, and to believe with Richthofen that the true lœss, wherever it occurs, is a sub-aerial deposit, formed in a dry central region, and that it owes its structure to the formative influence of a steppe vegetation.

The one weak point of Richthofen's theory is in the evident inadequacy of the current disintegration as a source of material. When we consider the immense area covered by lœss to depths varying from 50 to 2,000 feet, and the fact that this is only the very finest portion of the product of rock-destruction, and again that the accumulation represents only a very short period of time, geologically speaking, surely we must seek a more fertile source of supply than is furnished by the current decomposition of rock surface.

It seems to me that there are two important sources: I. The silt brought by rivers, many of them fed by the products of glacial attrition flowing from the mountains into the central region. Where the streams sink away, or where the lakes which receive them have dried up, the finer products of the erosion of a large territory are left to be removed in dust storms.

II. The second, and I believe, the more important source is in the residuary products of a secular disintegration which we will now consider.

In all regions where the soil is protected by a luxuriant vegetation the greater part of the insoluble products of disintegration remains *in situ*. Considerable portions of the continents have remained above water during long geological periods. Where this has been the case, and where the region thus exposed enjoyed a peripheral climate with a protecting vegetation and abundant generation of carbonic acid, the feldspathic rocks have been profoundly affected; granite and gneisses being decomposed often to the depth of several hundred feet. In regions underlaid by impure limestones of great thickness, a long continued existence as dry land results in the removal of the lime carbonate and the formation of a residuary accumulation of the insoluble impurities. Thus in Missouri, in the Ozark Mountains, the secular dissolving away of the limestones which contained from two per cent to nine per cent of insoluble silica and clay has left such residuary deposits 20 to 120 feet thick.

The decay of a rock mass progresses from the joints and cracks, by which the mass is divided into polygonal blocks, and the rate of this progress varies, in different rocks, with the nature of the mineral constituents and the physical condition of structure, texture, mineral combination, etc.

In granular rocks, as granites, syenytes, gneisses, granulytes, diorytes, etc., the product is an argillaceous sand or a sandy clay; porphyries, basaltic, trachytic rocks, generally produce ferruginous clays; impure limestones and dolomites undergo the greatest shrinkage of volume, leaving masses of sandy clay with chert separating the broken up representatives of such layers of shales and sandstones as were interstratified with them. Calcareous sandstones and shales also leave sands and clays.

The decay may extend to great depths before it reaches the cores of the larger polygonal blocks. Where this is the case, the disintegrated mass consists of the rounded cores of the blocks surrounded by the decomposition product of the rest of the mass.

Other things being equal, the granular rocks of a region will be nearly or quite reduced to a loose mass when the compact rocks like porphyries and basalts have still a large proportion of their mass represented by the rounded cores.

Even slate rocks—especially talcose, chloritic, hydro-mica and sericite slates—are often affected to considerable depths.

As different rocks are affected in very different degrees by this change, it happens that in regions underlaid by a diversity of rocks, the plane marking the boundary between disintegrated rock and still hard rock must be an exceedingly irregular one.

If we could imagine the loose altered rock removed where this process has been active in depth, the surface exposed would present a remarkable topography, one in which the hardness of the material would play no causative part. The prominent features, such as ridges and hills, would consist of the rocks that are most resistant to carbonic acid, as for instance, the soft clay slates and mica schists, as well as the hard quartzytes and sandstones. The action of frost does not concern us here, for it is comparatively a surface phenomenon.

The depressions would represent rocks more or less easily acted upon by carbonic acid, water and free oxygen, and to a greater or less extent, all rocks carrying a feldspar in abundance. We need not expect to find here inequalities of surface of the types produced by erosion. The depressions, instead of being valley systems caused by erosion by gravitating material, are necessarily, to a great extent, closed basins produced by the downward growth of the rock decay. Deep and shallow basins without outlets may be formed by the decay of the rock occupying the meshes of a network of less affected dykes or veins; but generally they owe their origin to the unequal distribution of the sources of dissolving reagents on the surface above, for instance, swamps and lakes, and to inequalities in the character of the rock itself. On the other hand, dykes more easily affected than the enclosing rock, and fissures causing the decay of their walls, would both give rise to remarkable defiles. These conditions are all presented in the most striking manner on the plateau of Central Asia.*

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* The importance of this decay in depth under protection from erosion seems to have wholly escaped the attention of geologists as a factor of general significance. Even the more remarkable local instances are rarely mentioned and only one or two have found references in text books.

Mr. Darwin states that the numerous travelers in Brazil have all been surprised at the depth to which the gneiss and other granitic rocks as well as the talcose slates in the interior have been decomposed.

Near Rio every mineral except the quartz has been completely softened, in some places to depths little less than one hundred feet.—Darwin, Geological Observations, Part III, p. 143. London, 1851.

Professor J. D. Whitney explains the accumulation, sometimes thirty feet thick of unstratified red clay, chert and galena in the Wisconsin lead region, by supposing it to be the residuum left by the gradual dissolving away of several hundred feet of impure limestone.—Geology of Wisconsin, vol. i, p. 121. 1853.

I have since observed and described the results of this process on a much larger scale among the dolomites of southern Missouri.—Geological survey of Missouri; Iron Ores and Coal Fields, p. 8. 1873.

According to Dr. Benza, the Neilgherry Hills, occupying an area of about 700 square miles in southern Hindostan are of granitic and hornblendic rock and are disintegrated often to a depth of forty feet.—Leonhard u. Brown, Neues Jahrb. für Min. Geol. u. Petrofact., 1838, p. 713.

The memoirs of the Geological Survey of India record the prevalence of this deep-seated decay in the crystalline rocks of that part of the world.

Dr. T. Sterry Hunt, who considers this decay to have taken place in Archæan time, after affirming its prevalence and depths in the southeastern States, sees in it the source of the extensive deposits of hydrated iron ores that occur along the base of the Blue Ridge. He also ascribes its removal in the northern country to the action of long-continued erosion and the final washing away by water and ice during the Glacial epoch.—Proceedings Bost. Soc. of Nat. Hist., vol. xvi, Oct. 15th, 1873.

As soon as we pass the limits of glaciation we find in southern Pennsylvania, Maryland and Virginia the crystalline rocks profoundly affected, especially the feldspathic kinds, but the decay extends also, with differences in kind and degree to the various slates. It may be well seen in the railway cuttings in gneiss between Philadelphia and Baltimore, and in the slates of Frederick County, Maryland.

In the report of the geological survey of Missouri presented in April, 1873, I have called attention to the extent of this decomposition in the granites, porphyries, and limestones of Missouri, and to the great economic importance of its resulting accumulations which I have called residuary deposits in connection with the iron, lead and zinc ores.

In October of the same year, Dr. T. Sterry Hunt described the prevalence of this same decay throughout the southeastern States, often to a depth of one hundred feet or more, considering it to date from a very early geological time.

Over a large part of Europe and America this accumulation has been removed by glacial action. We may assume that during the gradual approach of the glacial epoch the ground in the northern half of the northern temperate zone, as the mean annual temperature fell below the freezing point, became perpetually frozen and when covered by the glacial ice, the thickness of the glacier instead of being measured from the upper surface down to the former soil should be measured down to the bottom of the residuary mass of disintegrated rock. It seems to me that only on this supposition can we explain the enormous amount of the ground moraine that covers our northern country, and the predominance in it of the debris of local rocks. The whole of this loose material must have participated in the movement of the ice, though far more slowly than the overlying and more nearly pure ice. Thus at any given point, the material on and near the surface would represent localities considerably farther northward than that at the bottom. We can only thus account for the disappearance of the vast amount of residuary disintegrated material that must have existed over the surface of the Archæan feldspathic rocks of eastern British America. But in Northern Asia, north of the 40th degree of latitude there are no traces of a general glacial action such as existed in Northeastern America and Northern Europe. The

According to a verbal communication of Professor W. B. Rogers, this deep-reaching decay is general throughout the schists of the Southeastern States, where its depth often exceeds two hundred feet.

Mr. Alexander Agassiz and Mr. Thomas MacFarlane have both informed me that, at least the granitic rocks of the Andes are similarly affected.

Since this paper was written, I have had occasion to observe the immense extent of the disintegration in place that exists in the slates, diorites and syenitic granites of the foot-hills of the Sierra Nevada in California.

evidence indeed is all the other way. And yet, while the rocks of Southern Asia show extensive residua of disintegration, the results of a secular decomposition protected from erosion by an abundant vegetation, the feldspathic rocks of Northern China and of Central Asia are as free from this as are those of northeastern America.

The only answer to the question, what has become of them? is, that they have been blown and sifted and assorted by the winds, the heavier fragments remaining to be reduced by weathering and to form the stony steppes, the sand drifting in billowy waves over the country, and forming sand-deserts, while the fine dust floating in the air, an impalpable powder is deposited far and near, and, under the influence and protection of the steppe grasses, is transformed into the lœss.*

It is not many years since the glacial "till" was recognized as an extensive formation. The great development of the lœss has only just been demonstrated by the observations and generalizations of Baron Richthofen. The importance of each of these deposits seems to me to necessitate a recognition of the importance of the great residuary deposits as the source of both the others.

We have here suggestions that bear on many and varied geological problems, some of these which now occur to me I may be permitted to mention.

There are few problems in dynamical geology that have been considered more difficult to solve than the origin of rock-basins. Wherever my route between the great wall of China and the Siberian frontier lay through a region of crystalline rocks, I found that one of the characteristic features of the surface was the prevalence of basin-shaped depressions of all sizes hollowed out of the rock.* In other words, if filled with water they would have been lakes without outlets and with unbroken sides of rock. In some exceptional instances it was clear that systems of intersecting dykes had been less acted upon by the basin-making process than the intervening rocks, and the basins were formed in these last.

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* No one can realize the capacity of wind as a transporter of fine material, who has not lived through at least one great storm on a desert. In such a simoon the atmosphere is filled with a driving mass of dust and sand which hides the country under a mantle of impenetrable darkness, and penetrates every fabric; it often destroys life by suffocation, and leaves in places a deposit several feet deep.

The prevailing westerly wind carrying sand, carves and polishes the rocky crest of the Sierra Nevadas, and, as Mr. King tells me, has formed long wind-stream deltas, if I may coin the term, in the form of lofty sand ranges stretching, from each pass eastward, far out on the desert.

The often-cited instances of far-driven volcanic ashes show the ability of the wind to carry comparatively coarse dust through distances of several hundred miles, but it does not seem improbable that the finer particles may remain suspended while the wind makes a complete circuit of the globe. I witnessed on March 31st and April 1st, in 1863, a dust fog at Nagasaki, which lasted two days, and left only a just perceptible film of dust, observable only on the white newly-painted deck of a yacht. A similar fog occurred simultaneously at Shanghae, and both were cotemporaneous with a terrific dust storm which during two days shrouded the country about Tientsin in deep darkness.

I am indebted again to Mr. Clarence King, for the statement that dust fogs occur on the coast of California with the prevailing west wind; and this may be as he suggests, the finest residuum of the lœss dust of an Asiatic dust storm.

The rock basins of Scotland have been graphically described by Geikie, and while a great many of the countless lakes and lakelets in the region of the crystalline rocks of North America and Northern Europe are valleys of erosion with dams of glacial moraine material, vast numbers of them undoubtedly fill rock-basins. An ingenious explanation of the formation of these rock-bound depressions given by Ramsay and accepted by Geikie as the only reasonable hypothesis, is that the rock-basins of the loch and fiord kinds are due to unequal sculpturing by glaciers.

He says that where the bed of a glacier diminishes its angle of slope, the vertical pressure of the ice on its bed becomes greater, both owing to the lessened inclination and to the increased thickness of the ice, while farther down the incline the widening of the valley causes the ice to spread and consequently to diminish its thickness and pressure; the result being a rock-basin dammed by a rock-bar.

While this may be admitted, with some reservations, as a satisfactory explanation for many fiords and lochs cut in the declivities of a mountain range or of a steep coast, it is useless in regard to the lake-basins of flat countries, like Finland and British America. Geikie endeavors to use this hypothesis to explain also the rock-basins observed by me in Central Asia;† but it is still more useless here as an explanation, because there are absolutely no traces of glaciation in Central Asia, outside of the high mountain chains. These Asiatic depressions are rough and ragged, and the debris contained in them consists of ragged angular fragments of the local rocks, while the glaciated basins of America and Europe are smoothed and polished, and the debris they contain consists of the rounded and scored material of the drift.

The basins of Asia were emptied by wind, and those of Northern Europe and America were emptied by ice, but the wind and the ice were only immediate agents employed in rapidly emptying basins which had been long forming by a process common to both—the secular decay of the rock. I would thus seek the real cause, not in the unequal nature and action of the instrument, but in the unequal physical condition of the

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*** Pumpelly, Geological Researches in China, Mongolia and Japan, pages 72, 73, 26, Smithsonian Inst., 1866.**

† Geikie—Great Ice Age, pages 351–352, D. Appleton & Co., 1875.

material operated on. It is evident, I think, that we have in these residua an adequate source of material for the glacial drift and for the lœss, although other sources have probably contributed in some regions to the formation of the latter, as for instance, rivers which, fed by silt-loaded glacier-streams, sink away on the plains of the central area, leaving their suspended material to dry and drift on the surface.

In reply to some questions bearing on the possible sources of the lœss of the Missouri valley, Mr. Clarence King kindly informs me that during the Pliocene the entire surface of the great plains was covered by a sheet of water which he has called Cheyenne Lake. Its deposits, known as the Missouri Pliocene—2,000 feet thick at the western edge along the Rocky Mountains—become very thin at the eastern margin in Kansas and Nebraska. Throughout the eastern portion at all points over 150 miles east of the mountains, the material is exceedingly fine—so fine that Professor Brewer found that when shaken with water in a test tube it does not settle after standing a year. Furthermore, Mr. King (anticipating one of the generalizations of the forthcoming volume of his reports), says that there was a period of intense dryness affecting the whole region of the great basin, and at least a portion of the great plains. During this period there were exposed to wind-erosion, not only the surface of the plains, but the entire region east and west of the mountains that had been subjected to the Bad-land erosion. The countless cliffs and rounded outlines sculptured out of the soft Tertiary clays and marls which form the Bad-lands were particularly susceptible to wind-erosion. Finally, Mr. King summarizes his answer in these words: "The lacustrine basins of the plains and Rocky Mountains certainly afford sufficient fine material, the period of desiccation between the two floods of the Quaternary affords the necessary dryness, and the prevalent west wind would account for the transportation to the east."

In the warmly contested question as to the capacity of continental glaciers in excavating solid rock, the great extent of the "till" and of the modified drift have been adduced as an evidence of this power. It seems to me rather that the abundance of the drift material may be equally well taken as in great part but not wholly a measure of the effect of long-continued and undisturbed disintegration and of the transporting power of ice, and that a period of glaciation may be, as Rutimeyer insists, a period of comparative rest as regards excavation of hard rock.

The great source from which mountain glaciers derive their moraines is, as is well known, in the incessant rending action of cold—of constantly alternating contraction and expansion—

on the rocks of the peaks and precipices that rise above the ice. But a continental glacier, such as covered Northeastern America, had no such source of supply; for all the mountains were covered with ice and were thus protected from the operation of this process.

The great ice-sheet removed the residuary accumulation of loose material down to the solid rock; in doing this the loose material was ground together, producing much clay and sand; and besides this, the glacier grinding with this material under the immense weight of the ice on the solid rock, exerted an abrading and polishing action, the product of which must have been wholly very fine flour. I would thus measure the excavating action of the continental glacier in solid rock only by a small portion of the finest part of the glacial debris. For, since all the bowlders of the ground moraine have been abraded over their whole surfaces, the amounts of the product of abrasion from the loose residuary material on one hand and from the solid rock bottom on the other should stand to each other in nearly the ratios of their respective surface areas.

Not the least important suggestion is the influence of the causes we have considered on the succession of marine strata. Great areas like Southern China and the southeastern United States have remained as dry land from the Triassic period till now. Throughout this long lapse of time, disintegration and decomposition have been at work, and one has only to look at the excavations in Philadelphia and on the railroads running south from there to get some idea of what these agencies can accomplish. But the abundant vegetation of a moist, peripheral region has so thoroughly protected the residuary mass from erosion that the streams run clear, carrying to the ocean only soluble salts and the comparatively unimportant products of attrition. There are three methods by which these vast stores of slowly-prepared detritus can become available to form mechanical sediments, and all are rapid, in this sense, viz: that other things being equal, by each method, the ocean receives in a given time an enormously greater amount of sediment than it would receive had there been no such accumulation ready at hand. The *first* method is an encroaching sea-coast. The *second* is the removal of the residua as the ground-moraine of a continental glacier to furnish the ocean-border with enormous quantities of gravel, sand and clay, both from the frontal moraine and through the immense influx of debris brought by the rivers, at first from the melting ice, and, for a long time afterward, from the accumulated masses of gravel and sand brought down by freshets. The *third* method is through the mediation of the lœss formation. Let us imagine a region of granites, gneisses and impure limestones that has long been dry land, and has been covered by abundant vegetation, to be transformed into a dry, central area. The destruction of the protecting plants would expose to the fierce winds the loose residua of long periods of disintegration of the rocks. Under this process of a dry separation the material would be sorted, the finest carried to great distances, would find resting places only where under the protection of steppe grasses it could be fixed and transformed into lœss. The coarsest would remain to form the gravelly steppes, while the material of intermediate grain, chiefly siliceous sand, not capable of giving sustenance nor of being fixed, would drift in dune-like waves before the prevailing winds, transforming everything in its track into desert wastes.

We have in the immense lœss deposits of China, often more than one thousand feet thick, and in those of Europe and west of the Mississippi, which are often measured by hundreds of feet, the best evidence of the ability of the lœss-forming process to accumulate vast masses of fine material in a comparatively short time.

Let us now imagine this same region to be subjected to a reversal of this process, and transformed again into a transition zone, in the manner so strikingly described by Richthofen. As the rainfall gradually comes to balance and exceed the evaporation, the streams that empty into the ocean push their sources farther and farther back into the lœss territory, gradually tapping the Salt Lakes and taking up their tributaries until the ocean again drains the continent.

This is the period of the turbid waters. The rapid growth of systems of drainage and erosion in a lœss territory hardly admits of description. It is limited only by the amount of rain-fall. Coasts which during geological ages have received only limpid streams, and in whose waters the corals and lower organisms have worked heretofore, scarcely disturbed by the products of wave-erosion, are now continuously deluged with yellow silt.

The great silt-loaded rivers of the world are, in at least nearly all instances, streams which after running clear water for long ages, are now merely temporarily employed in making a rapid transfer of the lœss which is itself the product of a concentration by wind of the products of a slow disintegration which may have lasted from the Carboniferous period to the Post Tertiary.

When we consider not only the enormous volume of this silt, but also the fact that its extreme fineness causes it to be carried over great areas in suspension before it sinks, we can conceive that its effects may be catastrophic as regards the less plastic forms of life. This would be the case especially where the range of a fauna peculiar to a given coast is more limited than the area affected by the silt. The waters of the China sea for one hundred miles or more out to sea are yellow at the surface with lœss-mud along six hundred miles of coast; and when we consider the extreme slowness of deposition of this fine material, we cannot doubt that below the surface the silt extends eastward to the Kurosiwa, and follows the lower strata of this current far to the northeast.

This rapid transfer will, sooner or later, bring all the lœss into the ocean, and thenceforth the waters of the streams and the coast will be clear, or alternately clear and turbid, in proportion to the absence or frequence of oscillations of the coast level.

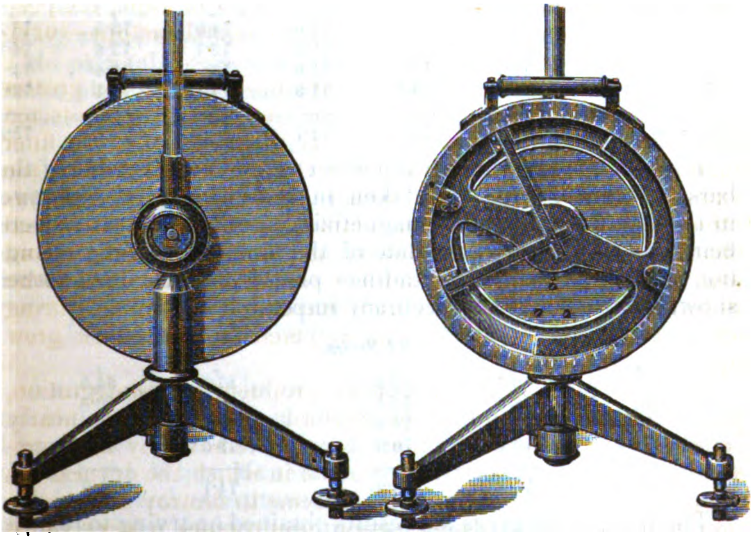
Environment and plasticity have been described as interregnant directing forces in evolution. It is during this period of turbid waters that the influence of environment and plasticity must be the most important factors in the evolution of life-forms; usurping, for a greater or less length of time, the position held for long ages by the purely biological factors—survival of the fittest, and heredity.

The very fine marine sediments are probably for the greater part the rapidly removed products of long-continued, protected disintegration and decomposition. If this be so, then the finer sand and clay rocks of any given column should record the extermination of all forms which, no matter how vigorous otherwise, were not able to adapt themselves to the radical change in their physical surroundings; and they should record also the operation of inorganic environment which then came in to break rudely the chain of descent, and introduce, during an interregnum, new laws of development under which grew up new forms.

In the removal of the residuary products of disintegration, glacial action and wind action perform parts that are nearly complementary to each other; for the removal by wind presupposes a central continental climate in which the dryness has temporarily become sufficiently extreme to destroy the vegetation, while a general glacial action presupposes a very moist climate.

ART. XVII.—*A method of Determining the Dip;* by N. D. C. HODGES.

THE magnetic polarity of a bar of soft iron is greatest when the bar lies in the line of the dip. This position of maximum intensity might be tested for by a small needle hung near one of the poles. This or similar ways have been used. The objections are that the rate of change in the polarity is small as the bar approaches the position sought, and the testing needle takes a less and less sensitive position, since the farther it is turned from the meridian the greater becomes the movement of the force of the earth upon it tending to bring it back. If, instead of one bar, two bars joined at right angles at a point near their ends be used, these difficulties may be avoided. When such a compound bar is placed so that the two branches make equal angles with the line of dip, the effect on one of them is to make the lower end a north pole and its upper end a south, on the other the lower a south and upper a north. Supposing the bars exactly similar, the two poles at the point where they are joined, will neutralize one another; and any needle suspended near that point will hang in the meridian unaffected by the bars. A slight turning of the compound bar will render the field in which the needle hangs either a north or south, and it will move to correspond. To eliminate the effect of any permanent magnetism in the iron, four readings may be taken; first



both bars above the line of dip, then both below or in a position nearly 180° from the first, finally moving them so as to present the other side to the needle in each of the first two positions.

The first series of observations were made to see how constant the readings would be and how sensitive the method. They were all taken within twenty-four hours. After two of them the testing needle was changed from hanging horizontally to hanging at an angle of 45°. This was done to see if the poles at the outer ends of the bars had any influence. If the axis of the testing needle made equal angles with the two bars, the outer poles being at equal distances from the poles of the needle, would counteract each other as far as turning the needle. The results were constant within the limits of observation. The separate readings differed much more from the mean in the beginning. The bars seemed nearly free of permanent magnetism finally.

1st Series.

A,	77°·	77°·2	76°·7	75°·6	74°·5	73°·5	73°·1
B,	71·	70·7	70·6	71·6	72·7	73·8	74·2
C,	70·3	70·7	71·	71·8	73·	74·4	74·
D,	76·2	75·9	76·5	75·9	74·4	73·1	73·
Average,	73·6	73·6	73·7	73·7	73·7	73·7	73·6

The second series shows the effect of magnetizing one of the bars. The first three were taken in the morning, the last two in the afternoon, after the magnetizing. While the latter were being made, the magnetic state of the iron was rapidly changing, as the corresponding readings placed opposite one another show, and rendered any accuracy impossible.

2d Series.

70°·2	70°·5	69°·9	87°·5	84°.5
77·	76·4	76·1	57·5	60·8
76·9	77·2	76·4	72·	70·
70·3	70·1	70·5	79·5	80·
73·6	73·6	73·2	74·1	73·8

The third series gives the results obtained on trying to remove the magnetism by rapping the bars with a hammer after each determination. The separate readings approached the value of the inclination. The averages remained constant within the limits of the instrument.

3d Series.

84°·3	83°·2	80°·9	80°·2	80°·3
60·2	62·5	65·4	66·4	66·8
69·6	70·1	72·6	73·	72·4
81·	79·3	76·3	75·2	76·7
73·9	73·8	73·8	73·7	74·1 ?

The fourth series of results are those before and after heating the bars to redness for three or four hours.

4th Series.

Before heating.		After heating.				
66°·4	66°·2	67°·7	68°·4	68°·5	68°·9	68°·9
79·9	80·5	77·5	78·9	78·3	77·7	77·5
76·3	76·	79·1	78·7	78·2	78·6	78·6
72·1	72·2	70·	70·	70·1	70·1	70·
73·7	73·7	73·6	74·	73·8	73·8	73·75

The instrument used was constructed to test the principle of the method. The accompanying cut shows quite clearly the different parts. The views are of the front and back of the divided circle. The iron bars are shown in the position to the north and above the line of dip, the initial position of the above description. They are on a frame which turns about the center of the circle, and from which they can be easily detached and reversed. The other plan shows the testing magnet in the casing at the middle of the disk.

No particular care was taken to have the plane of the circle in the plane of the magnetic meridian. As a self-registering apparatus, the instrument seemed faulty; as at no time during the experiment did the magnetic state of the iron remain constant.

Physical Laboratory, Harvard College, Dec. 6, 1878.

ART. XVIII. — *On a Group of dissimilar Eruptive Rocks in Campton, New Hampshire*; by GEORGE W. HAWES.

AMONG other results of the petrographical studies made by me under the direction of the New Hampshire State Survey,* I have shown that the rocks of the dikes, abundantly scattered through the White Mountains, are very diverse in composition and in mineral constituents. Independently of the results of decomposition, which has in many cases widened original differences, rocks which to the eye appear identical are often found, on microscopic examination, to be fundamentally different; and the rocks of closely adjoining dikes not infrequently have nothing in common save their geological position. This feature is quite striking, especially when considered in connection with the uniform character of the eruptive rocks in some adjoining regions. To illustrate it I have made a study of a small group of dikes in Campton where this diversity is very well exhibited.

The Livermore Falls are in Campton, but they are only two miles distant from the larger and more accessible town of Plymouth. The Pemigewassett river has here cut a gorge through a hill, and in the walls of this gorge the eruptive dikes are very conspicuous. The gorge is not long, and the dikes, five in number, are all embraced in a portion of it which is little more than a hundred yards in length.

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* Geology of New Hampshire, Hitchcock; Part IV; Mineralogy and Lithology.

Attention was called to these dikes in 1837, by Professor O. P. Hubbard of Dartmouth College.* His description of them is accompanied by a picture of the gorge, which shows their forms and relative position; but as the rocks could only be identified by microscopic examination, he did not attempt to classify them.

The rock through which the dikes intrude is mica schist, which presents its usual diversities, caused by variation in the proportion of the essential ingredients and the presence of accessories. The strike is northeast and the dip is variable. These rocks are considered to be as old as the Silurian, and Professor Hitchcock regards them as still older.

The five dikes cut the schist almost at right angles; all are nearly vertical, and parallel to one another. A bridge has been built across the gorge from which all the dikes can be seen except the one directly under the bridge. From their position with reference to the schists, it is inferred that the fractures resulted from the action of the same forces acting in the same way. Yet among these five dikes, there are found four very well distinguished rock species. I will describe these rocks in the order in which they occur, beginning with the one highest up the stream.

Dike No. 1, is seen only upon the left of the stream. It is about three feet wide; the rock is black in color, compact and apparently nearly homogeneous. The study of some thin sections indicates that it is a *diabase.* It was originally a mixture of augite, a triclinic feldspar and titanic iron, but all its ingredients are partially altered. The augite is in process of alteration into hornblende; some of its grains being still intact, some being partially and others wholly altered. The feldspar is more or less changed, but shows its polysynthetic character throughout. The titanic iron oxide is extensively altered into the grayish white product that is called leucoxene. Minute apatite crystals are seen in the section. Calcite, as a decomposition product, fills cavities that are apparently made by the removal of some other mineral; these cavities are also often partially filled with analcite, which has a cubic cleavage and exerts a very feeble action upon polarized light. The analyses of all the rocks described are placed together on a subsequent page.

Dike No. 2 is eight feet wide. The rock is black in color, and is composed of a very fine almost homogeneous ground-mass, in which small black shining crystals are porphyritically developed. The thin sections indicate that this is *diorite.* It is a mixture of hornblende, a triclinic feldspar, and titanic iron oxide. The large crystals are of hornblende; it is here an original product, and has not resulted from the alteration of pyroxene, as in the last case, since its well-formed crystals are developed in the common hornblendic forms. Many of them are twin crystals, the twinning plane being as usual parallel to the orthopinacoid. Both the large porphyritic crystals and the small ones in the ground-mass are fresh and unaltered. The feldspar is in part fresh and in part somewhat altered. The basic nature of this rock, as of the last, indicates that the feldspar is a variety low in silica, but its species can not be determined by optical means. The iron oxide is quite abundant, and in part well crystallized. Sometimes a large opaque hexagonal section is met with which is probably menaccanite. The rock contains a little apatite. Calcite, some zeolitic, mineral of an undetermined species and a little chlorite exist as decomposition products.

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* Am. Jour. Sci., I, vol. xxxiv, p. 105.

Dike No. 3 is ten feet wide, and is filled with a massive rock fine in texture and white or grayish in color. When a section cut from a white specimen is examined, the rock is seen to be composed largely of small, quite well defined orthoclase crystals. The meeting of these forms angular corners, that are for the most part filled with lime and iron carbonates and chlorite, though some are filled with quartz. In sections from the darker specimens it becomes evident that the aggregate in the angles is a decomposition product, for remnants of a dichroic green mineral, which is probably hornblende, are left there. It contains in addition some magnetite and some specimens show a little pyrite. The rock is a very fine grained syenite similar to those which occur in different parts of the State.

Dike No. 4 is about a hundred feet from No. 3 but is identical with it in all respects. Dike No. 3 separates into two branches in the middle of the stream, and forms two dikes in an island there situated, and it is not improbable that No. 4 may unite with it at some point.

Dike No. 5 is about seventy-five feet from No. 4. It is very narrow, being only about a foot wide, but it has several branches as wide as itself which unite with it at acute angles. This again like No. 2 is composed of a fine grained ground-mass in which larger crystals are developed, but when the sections are examined it is found to be an *olivine diabase.* The porphyritic crystals are in part perfectly formed augite crystals, and in part well formed olivine crystals which are mostly changed to serpentine. The finer portion of the rock is composed of augite, a triclinic feldspar, titanic iron and minute brown dichroic crystals of hornblende. Some small amygdaloidal cavities were observed containing sphærosiderite, calcite and analcite.

In these five closely adjoining dikes there are, therefore, four very different kinds of rocks. Selecting specimens as fresh as possible from the different dikes I analyzed them with the following results:—

	Diabase. Dike No. 1.	Olivine diabase. Dike No. 5.	Diorite. Dike No. 2.	Syenite. Dikes Nos. 3 & 4.
Silica	41·63	42·77	41·94	58·25
Alumina	13·26	14·06	15 36	18·22
Iron sesquioxide	3·19	2·72	3·27	1·07
Iron protoxide	9·92	8·34	9·89	5·96
Manganese protoxide	·27	·15	·25	·10
Titanium dioxide	3·95	2·35	4·15	*tr.*
Lime	8·86	11·47	9·47	1·51
Magnesia	7·31	9·72	5·01	*tr.*
Soda	2·49	1·89	5·15	4·19
Potash	3·32	1·43	·19	5·59
Carbon dioxide	5·20	1·62	2·47	4·75
Water	1·35	2·74	3·29	·85
	100·75	99·26	100·44	100·49

Though I have mentioned the existence of decomposition products, they are present only in minute quantities; and as in these very compact rocks the new compounds must have been formed from the old, I think the above analyses represent very nearly the original composition of the rocks, with, however, the addition of the water and the carbon dioxide.

Between the light and dark colored rocks there is a wide difference, which indicates that the reservoirs from which they were ejected contained fused material of very different compositions. The black rocks are nearly alike in composition, but their differences are such as might account for the variation in mineral constituents. The quantivalent proportion of the sesquioxides to the protoxides is considerably higher in the diorite than in the diabases, and this is a condition favorable to the formation of diorites, as shown by the higher percentage of alumina usually found in the hornblende of eruptive rocks. The larger percentage of magnesia may have favored the formation of olivine in one diabase and not in the other. But the presence of compact and porphyritic materials in different dikes, though of nearly the same composition, indicates different conditions of cooling and crystallization, and these may also have been a cause of the mineral distinctions.

In the adjoining Connecticut Valley the red sandstones are cut by numerous dikes. Many of these rocks and others geologically related have been microscopically examined by E. S. Dana,[*] and some were analyzed by myself.[†] It was shown that these large dikes which are so characteristic of the Mesozoic red sandstones of this coast are, wherever found, essentially uniform in composition and mineral constituents. They are compounds of labradorite, augite and magnetite, and vary only in the extent of their alteration. Professor Dana has concluded from this uniformity and their wide distribution over the Atlantic slope from Nova Scotia to North Carolina, that the dikes reach to profound depths.

It is most probable that the large and small dikes that are so common among the crystalline rocks of New Hampshire, occupy fissures which were made during the elevation of the mountains. In the process of elevation, variable conditions must have been introduced in the strata at different places and times, on account of the conversion of mechanical work into heat, as has been shown by Mallet and others, and this would have modified the depth at which fused materials would be found beneath the surface. If partial crystallization took place before eruption, as in the case of many modern volcanic rocks, very variable conditions might also have been introduced at different times for their solidification. The Mesozoic sandstones referred to do not occupy a position that indicates a great strain upon the earth's crust at the time of fracture, but are found in areas of gentle subsidence, and the uniformity in the dikes that characterize these regions, when compared with the diversity in the dikes of the mountain region of New Hampshire, is as striking as is the contrast in the geological features of these two areas of eruption. A sinking of the earth's crust might result in profound fractures which would reach to the homogeneous zone beneath the sedimentary formation. The crushing attendant upon elevation might fuse sedimentary deposits at various depths, and produce fissures that would be filled with the most diversified material.

ART. XIX.—*Notes on the Mesozoic Strata of Virginia;* by WM. M. FONTAINE.

[Continued from page 39.]

Hanover Area.—This, the northern portion of the Richmond belt, shows considerable differences from the Richmond coal field. The structure is not that of a basin, but it contains one or more broad anticlinals, the beds on the west side dipping northwest against the Azoic, and on the east passing with a northeast and east dip under the Tertiary. We have here also two series. The lower has the general character of the lower series of the Richmond Coal field. It has no workable coal, and only a few thin and impure layers, at most, an inch or two in thickness. Plants occur, some of the species found in the Richmond coal field being discovered here also, with other, somewhat later types. Taken as a whole, this part of the belt contains, as Rogers long ago showed, strata somewhat younger than those of the productive portion of the belt lying farther south. Much of the vegetable matter seems to have been drifted into its present position. I observed a very curious patch of coal, very locally deposited, which seems formed entirely of the epidermal tissue of leaves, which have been drifted together and packed closely in layers. These leaves seem to have been principally those of *Macrotæniopteris magnifolia.* The upper series also presents a general character like that of the upper series of the Richmond coal field, but some of the peculiar features found in that field are here much more exaggerated. The exposures are very poor, and it is very difficult to make accurate examinations. The greater portion of this series is composed of sandstones with subordinate beds of shale. The sandstones of the uppermost portions, especially those found in the northern extremity of the tract, are remarkable for the unsorted and undecomposed character of the material composing them. This material is a mixture of quartz, pinkish feldspar and dark mica, easily recognized as coming from certain granitoid gneisses, which are found in force along the southwestern side of the area. On compression, this material forms a rock closely like the original gneiss. On the northwestern edge of the area, along the North Anna River, this finer matter has associated with it large, partly rounded stones, coming from the same granitoid gneiss. On this stream the stones make up the greater part of the mass. They are imbedded in a matrix of the above mentioned finer material. The stones are often quite fresh, and sometimes of very large size. I saw one granite bowlder ten feet through, and not fully exposed. Many are two, three, and four feet in diameter. I am not able to say what connection, if any, these stones have with the bowlders of the interior belts. They were deposited before the cessation of the emission of igneous matter, as they are penetrated by several trap dykes. They form certainly the youngest beds of the series. The dip is very obscure, but appears to be to the northwest. When these beds are traced to the eastern side of the area, where they pass under the Tertiary, we find that the number and size of the stones greatly decreases. The beds now take in fragments of the shale, and other strata of the lower series, which feature is never seen on the western side. This of course should be the case, if the eroding force acted from the west and southwest. These uppermost beds pass, as it appears, up into the strata which occupy the border belts, and which here overlap, as stated before, this area. I have not seen any similar beds of stones, on the west side of the Richmond Coal field, and do not think that they exist there, though my observations are not extensive enough to decide the question positively. The lower and middle portions of the series are much like the upper series of the Richmond Coal field. They contain some thin films of coal, and some plants, too poorly preserved to be of much value in determining age, though so far as their evidence is to be taken, the series is certainly younger than the Richmond coal-bearing strata. A large amount of drifted vegetation, principally trunks and limbs of coniferous trees, now changed to lignite, or silicified, is found especially in the upper beds. The amount heaped up at certain horizons, is sufficient to give the appearance of small, locally developed coal seams.

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[*] This Journ., III, viii, 390. [†] Ibid, III, ix, 185.

The Fredericksburg Belt.—In this, also, we may recognize two series, a lower, about 150 feet thick, and an upper, still thicker. Both vary so much in the composition and structure of the beds, that it is difficult to give any correct idea of them without going into details, which would require too much space. The lower series, however, is more constant in composition, and may be generally recognized by its physical features, which is not the case with the upper. It is composed mainly of a curious sort of sandstone (Rogers' feldspathic sandstone) which possesses very little coherence. This is due to the fact that it is mainly composed of grains of sand, usually fine, surrounded by a non-plastic white earth, resembling kaolin. This is a composition which indicates that the sorting action of water has not been brought into play. This is farther indicated by the structure of the mass, which is usually affected with false bedding, and often resembles a mass of agglutinated sand. The planes of the false bedding are very short, and shift rapidly. The strata lie nearly horizontal, inclining slightly to the southeast. Small stones are often scattered through the mass, and beds, nests, or pockets, of larger stones, occur at different horizons. These stones are sometimes four to six inches in diameter. All the stones are either quartz, which is most abundant, or Potsdam quartzite. The lower portion is, on the whole, more siliceous and coarser. The upper part is often a fine-grained powdery mixture, of siliceous matter and kaolin, which shows very sudden changes of texture and a complicated cross-bedding. This material is very significant, as there is no rock in the Azoic of the adjacent country which could by its erosion yield it. The Azoic rocks to the west and northwest are mica slates, argillites, etc., which in decomposing yield yellow, reddish, and bluish clays, and yellowish or reddish sand. From the character of the finer matter, and of its contained fragments, it is clear that much of it was derived from the Potsdam strata, on the west of the Blue Ridge. As I shall have frequent occasion to refer to this Potsdam material, a brief description of the occurrence and character of the parent rocks will be required.

In my article on the "Primordial Strata of Virginia," published in the May and June numbers of this Journal for 1875, I gave some account of certain varieties of the Potsdam strata, which occur in great force near Rockfish Gap, on the head waters of South River, a branch of the Shenandoah River, and at the entrance of the gorge cut by James River, at Balcony Falls, where it crosses the Blue Ridge. They also are exposed along the entire lower course of the Shenandoah, and on the Potomac, a short distance above Harper's Ferry. At this latter place also, they are much crushed and fractured. The rocks, at these points, are much shattered, and lie in their original beds so loosely, that they may be removed with a pick. The most notable of these rocks are compact, vitreous quartzites and peculiar sandstones, which have the grains of sand imbedded in a white, non-plastic, argillaceous matter, like kaolin. The latter graduate, by loss of quartz grains, into shales or slates of a white color, composed of the non-plastic matter. All are strikingly white and void of ferruginous matter. It is from these strata that the Potsdam material comes, which is scattered so abundantly over portions of the eastern border of the Atlantic slope, and this appears to be the source of the precisely similar white matter, which forms the finer material, of the lower series of the Fredericksburg Belt. As nothing like it is found among the Azoic strata, fragments of this material may easily be recognized when found east of the Blue Ridge. Indeed, they are as well characterized as fossils. Were there any doubt attending the assigning the source of these stones, from physical evidence alone, to the Potsdam, it would be put at rest by finding, as we often do, the well-known marks of *Scolithus linearis* in these erratics. This lower series is best exposed at the town of Fredericksburg, where it, in its more coherent portions, yields a building stone, which was formerly used to a considerable extent.

The lower series passes up into a higher system of beds, constituting the upper series, which is marked by a smaller proportion of the white incoherent beds, so characteristic of the lower, and by a predominance of clays of reddish, yellowish, and bluish colors, and of reddish and yellowish sands. These clays and sands increase in amount as we follow the belt northward. Near Alexandria, between Washington and Baltimore, and near the latter city, they constitute the whole of the upper series. The material of these beds comes from the decay of the Azoic on the west. These clays and sands also are very irregularly bedded. The sands especially, are much affected by cross bedding. From Alexandria northward the lower series is rarely seen, being too deeply buried. At Baltimore it appears in the lowest white clays and sands dug in the base of the hills. Toward the close of the formation of these strata they were invaded by some agent which planed them off, or scored them more or less deeply into channels, and brought along with it quantities of sand, gravel, large rounded stones and slightly worn blocks, often of very large size. This material was deposited in a confused manner, and is usually very different from the beds on which it reposes. This agent seems to have acted from the northwest. From Fredericksburg to the Potomac, the gravel and rounded stones are composed of quartz, Potsdam quartzite, and sandstone. In the vicinity of Alexandria, Potsdam bowlders predominate over the quartz. They are commonly six or eight inches in diameter, and often attain the dimensions of one and two feet, showing frequently *Scolithus* markings. They are found over the surface of the Mesozoic here, five or six miles from the Potomac and up to the Azoic border, often forming belts of stones packed in comminuted Potsdam matter. Throughout the entire belt, the large, slightly worn blocks, are composed of crystalline rocks, from varying distances to the west and northwest, all the way to the Blue Ridge. These are not rarely four or five feet in diameter, and sometimes six or seven feet. Near Fredericksburg, we may see large stones formed of the characteristic epidotic and chloritic schists, composing the Blue Ridge on the west. Near Alexandria, large, slightly worn masses, having a diameter of four or five feet, are found of the peculiar siliceous and chloritic schists composing the Blue Ridge at Harper's Ferry, along with gneiss and mica schist from nearer localities. North of the Potomac, over the lignitic and iron-ore clays, between Washington and Baltimore, which belong to the upper series, I did not see any Potsdam material. The rounded stones and gravel are quartz, but the Azoic erratics abound. The iron-ore clays near the Relay House have been deeply scored, and the excavations filled with coarse sand, gravel, masses of the iron-ore, and Azoic erratics. But this action does not seem to have been confined, in all places, to the upper portion of the series. Near Neabsco Station, on the Fredericksburg and Alexandria Railroad, I found near the Azoic floor, and under a very considerable thickness of the upper sands and clays, a heterogeneous mass of angular Azoic matter in large blocks mixed with worn and rounded stones, of quartz and Potsdam sandstone, imbedded in blue clay. This drift matter, by the eroding and sorting action of the streams which cross it and pass into the Tertiary or Cretaceous areas, has been carried over to a distance, greater or less according to the particular conditions, on the surface of the more recent strata. It has by the same action been concentrated near the streams. Also in the space between these rivers, surface erosion and other causes have caused it to pass over a short distance on the newer beds, but it soon disappears within the areas occupied by such beds. In Virginia we have no means of determining whether the drift follows the surface of the upper series as it passes eastward under the Tertiary, but in Maryland it evidently passes eastward under the Cretaceous. Thus the wells bored to the southeast of Baltimore penetrate it on entering the clays and sands of the upper series. I have carefully examined the Maryland Reports for information on this head, and find that they give evidence that this bowlder deposit passes as far to the southeast as its horizon has been reached.

Fossil Plants.—These can be only briefly noticed. I have found a large number of well preserved plants at Fredericksburg in the lower series. They occur in a gray clay or shale, which rests on a bed of cobble-stones. I owe the discovery of the deposit to Professor P. R. Uhler, President of the Maryland Academy of Sciences. The material which imbeds the plants is not laminated, and the plants all seem to have been drifted. Considering their mode of occurrence, the small amount of change exhibited by some of them is wonderful. As the deposit is very local, it has hitherto escaped attention almost entirely. Many of the plants retain their entire structure, and are only colored brown. I have some which seem still to possess their chlorophyll! They have a decidedly green color. They are principally Conifers, Cycads and Ferns. No species of the Richmond Coal field are found here, but a few show affinities with Rhaetic plants. With the plants above named, I find certain netted-veined leaves, which by their nervation cannot be distinguished from Angiosperms. Had they been found with Cretaceous or Tertiary plants I think no one would hesitate to consider them as such. As, however, they occur with a well marked Upper Jurassic flora, I hesitate to pronounce them to be Angiospermous plants, without a more careful study and extended comparison, than I have as yet been able to make. They are certainly not "Dictyophyllum," which is the genus of fossil ferns that stands nearest to them. But when we find such a development of undoubted Angiosperms in the lowest Cretaceous beds of New Jersey and of the west, we should expect to find, at least, their ancestors in the Jurassic flora.

This flora, as a whole, is decidedly younger than that of the Richmond Coal field. Its rather complex type will require a careful study to fix the age, but from my preliminary examination, I conclude that it is nearly of the age of the Upper Oolite of England, an age long ago assigned by Rogers to these beds. The general facies is much like that of the flora of Sutherland in Scotland, figured in part by Hugh Miller in his "Testimony of the Rocks," which he considered as being partly Liassic, but which Mr. Judd shows to be all Upper Oolite in age. R. C. Taylor found at another locality near Fredericksburg, but on the same horizon with mine, a few plants which he figured and described, in a communication published in the Trans. Geol. Soc. Penn., vol. i, 1835. These plants he considered to be Oolite in age.

In the upper series at Fredericksburg I have found, in a state of preservation permitting determination, only a few twigs of Conifers with leaves. But this series, both here and to the northward, is remarkable for the great quantity of lignite and jet which it contains, produced from the trunks and limbs of coniferous trees. The most abundant tree seems to have had a wood very like that of the white pine (*Pinus strobus*). To judge from the amount of this lignite in the upper series of the belt, the country must have been covered with extensive forests of coniferous trees, at the time of the formation of the beds composing it. The trunks are sometimes piled so thickly over each other that they produce the appearance of a prostrate forest. Near Neabsco Station we find such a state of things. The trunks are here flattened and imbedded in a blue clay. Great quantities of lignite occur in the clays of the upper series, especially the clays which Mr. Tyson calls "iron-ore clays," which are found between Washington and Baltimore. In these clays, stumps of Cycads, belonging to at least two new species of the genus *Cycadoidea*, are found. The blue clays at Baltimore yield some beautiful ferns of Wealden type. All the attainable evidence points strongly to the conclusion that the age of these upper beds is Wealden. Professor Rogers mentions that they yield at Fredericksburg two or three species of ferns and stumps of Cycads of the genus *Cycadoidea*. None of these have been seen by me. What the relation of these beds is to the lower clays of New Jersey with Angiospermous leaves, is not known, though, no doubt, the New Jersey beds are somewhat younger.

Professor Wm. B. Rogers has long held the opinion that these upper beds are Wealden in age. This is also the opinion of Professor P. R. Uhler. Mr. P. T. Tyson also held a similar belief which he based not only on the plants, but on certain fresh-water shells (Unios?) which resemble Wealden species. The beds in question, however, seem to be by all others considered as Lower Cretaceous, as it would appear, solely from their underlying known Cretaceous marine strata.

[To be continued.]

Art. XXI.—*Notices of Recent American Earthquakes.* No. 8; by Professor C. G. Rockwood, Jr., College of New Jersey.

In these notices, as heretofore, those based upon *single* newspaper notices and which could not be otherwise verified, are printed in smaller type and the source of the information is indicated.

For information received, I am again indebted to J. M. Batchelder, Esq., of Boston, who has kindly given me the benefit of his lists; and to the U. S. Monthly Weather Review.

1877.—July 13. From Coban, a place in the central part of Gautemala, east of the mountains, there were reported thirteen or fourteen shocks at 5.15 A. M., the direction E. to W.—(U. S. Weather Rev.)

From the same place are the following four.

July 20. At 10.05 A. M. two slight shocks, E. to W.

July 27. At 8 P. M. a slight shock, lasting a few seconds.

Aug. 27. At 11.35 A. M. three shocks from the north.

Sept. 10. At 10.45 A. M. two shocks, lasting seven seconds and sufficiently strong to sway the façade of the church.

Sept. 10. A slight shock felt about 2 A. M. at Cambridge, Mass. Eight hours later the shock occurred along the Delaware River, already noted, III, xv, p. 25.

Nov. 16. The shock about 2.30 A. M. at Knoxville, Tenn., as noticed, III, xv, p. 27, was from S.W. to N.; and was felt also at Murphy, N. C., where the direction was W. to E. and the duration fifteen seconds.

Nov. 21. At Coban, Gautemala, at 10.16 A. M. two vertical shocks, and at 10.37 P. M. a number of small shocks lasting forty seconds.

Nov. 24. At Red Bluff, Cal., two shocks at 6.30 and 6.50 A. M., the first lasting twenty seconds, and being from E. to W. This was felt also at San Francisco.

Nov. 26. At Coban, Gautemala, at 9.57 A. M. a few vertical shocks lasting twenty seconds.

Dec. 14. A strong shock at 7.15 P. M. in Callao, Peru, the undulation being from N. to S.—(N. Y. Times.)

Dec. 18. At Beachburg, Ont., two shocks, the first between 1 and 2 A. M., the second between 5 and 6 A. M. and quite severe.

1878.—Jan. 2. A slight shock about 7 P. M. in Louisa and Hanover Counties, Va., accompanied by a roaring sound.

Jan. 8. Two slight shocks at 10.30 P. M. at Cairo, Ill.

Jan. 23. At 7.55 P. M. a strong shock, lasting thirty seconds, occurred on the southern coast of Peru. It was severe at Iquique and Arica, and was accompanied by a subterranean sound; but it was most destructive in the interior, where some houses were shaken down. But little damage was done on the coast; the sea was comparatively quiet and there was no tidal wave.

At Iquique lighter shocks followed with short intervals during the 24th and 25th, over *forty* distinct shocks being counted. A second heavy shock occurred at 8.30 P. M. of the 24th.

Jan. 27. The harbor of Callao was greatly disturbed by a series of tidal waves. The heavy surf began about 3.30 A. M. and continued during the day, causing great damage to the docks and sea-wall. inundating the English railroad station and resulting in some loss of life. The movement came from the north.

Feb. 5. A shock at 11.20 A. M. at Flushing, N. Y., sufficient to break windows.—(U. S. Weather Rev.)

Feb. 26.—A shock at 11.56 A. M. at San Francisco consisting of three vibrations N. to S., lasting five seconds.—(U. S. Weather Rev.)

Feb. 27. A severe earthquake occurred at 5 P. M. at Reykjavik and other places in the southwest part of Iceland. It was connected with a volcanic eruption which began the same night and continued for more than a month. The new volcanic openings, fourteen in number, were situated in the Raudaskal valley, about four miles northeast of Mt. Hekla.

March 12. At 4 A. M. a severe shock at Columbus, Ky., causing the fall of a portion of the bank of the Mississippi.

———————. The same day two shocks at Milford, Vt.—(U. S. Weather Rev.)

March 17. Two sharp shocks at St. Thomas, Lower California. —(U. S. Weather Rev.)

March 18. A slight shock at 6.30 A. M. at Tacoma, Washington Ter.—(U. S. Weather Rev.)

April —. "In the early part of the month," an earthquake occurred at Manizales, United States of Columbia, overthrowing a church tower.

April 12. About 8.40 P. M. a destructive earthquake occurred at Cua in Venezuela. This was a town of about 3,000 inhabitants, situated on the River Tuy, in N. lat. 10° 8′ 15″ and W. long. 66° 55′ from Greenwich, the center of a flourishing agricultural district. The height above the Caribbean Sea is 232 meters. The center of the town is situated on a small hill about 20 meters above the lower part. The hill is composed of gneiss, micaceous and chloritic schists, rising rather steep toward the W.S.W. It is surrounded by strata of clay and marl, covered by a deep stratum of alluvial soil, and resting on dark limestone and argillaceous schists. This upper town was destroyed, being reduced to a heap of ruins in less than two seconds. About 300 lives were lost and property destroyed to the amount of £300,000. The lower town suffered very little. The direction of the shock was from E. 15° N. and the angle of emergence was found by A. Ernst of Caracas to be about 60°. The center could not have been very deep, as the destruction was limited to an area of one square mile. The transverse wave however was felt one hundred miles distant and occurred in Caracas, distant in a straight line twenty-six English miles, at 8^h 41^m 34^s. Lighter shocks continued to be felt at intervals up to May 4.

For the greater part of the above I am indebted to an article by Mr. Ernst, in Nature, vol. xviii, p. 130.

April 15. At Glendive, Montana, on the Yellowstone River, there were three shocks, following each other at intervals of half an hour.

April 23. At Loreto, on the Gulf of California, a severe shock of two or three seconds at 10 A. M.; the first of a series lasting till May 3.—(U. S. Weather Rev.)

April 28. A severe shock, felt at Caracas at 8.30 P. M. destroyed a large part of the town of Ocumare, about twenty miles east of Cua and in the same valley.

April 29. Shocks were again felt at LaGuayra, Caracas, Porto Cabello and Valencia, in Venezuela.

May 8. At 8.25 P. M., a shock from N. to S. and sufficiently violent to stop clocks, was felt in the valley of the Sacramento Cal., from Red Bluff to Sacramento City, and also west of the Coast Range in Mendocino County.

May 14. A severe shock was felt at Guayaquil about 6.40 P. M., preceded by a loud noise. There was a less violent shock at 9 A. M. of the 15th.

May 15. A severe earthquake occurred at 8.35 P. M. at Tacna and Arica, Peru.

May 21. A shock at San Bernardino, Cal.—(U. S. Weather Rev.)

June 4. A light shock at 12.28 P. M. at San José, Costa Rica.

June 9. A strong shock at the same place at 4.34 P. M.

June 11. On the night of the 11th and 12th, four shocks were felt at Los Angeles, Cal., as follows; at 11.12 P. M. a distinct shock, at 11.20 P. M. a violent shock, duration five seconds, motion N.W. to S.E.; at 2.30 A. M. a light shock; and at 6.30 A. M. a slight tremble.—(U. S. Weather Rev.)

June 14. A slight shock at Cimarron, N. M.—(U. S. Weather Rev.)

July 2. Two light shocks at Campo, Cal., at 5^h 55^m 30^s (A. M. or P. M.?) from S.E. to N.W. with a noise resembling thunder.—(U. S. Weather Rev.)

July 11. A severe shock at midnight at St. Thomas, W. I.

July 16 and 18. Two severe shocks in Hayti.

July 21. A slight shock at 5 A. M. at Salt Lake City.—(U. S. Weather Rev.)

July 26. A slight shock, direction north and south, was felt at 8.25 A. M. at Los Angeles, Cal., and at San Gorgonio, San Bernardino and other places in the mountains east of Los Angeles.

July 27. At 7.30 P. M. a strong shock at San José, Costa Rica.

Aug. 3. A severe earthquake occurred at 2.15 P. M. in the Island of Martinique, W. I. The vibrations continued fifteen seconds, and in the town of Diamant several buildings were thrown down.

Aug. 9, 13, 14, 15, 22, 30. At San José, Costa Rica; on 9th at 4.15 A. M. a feeble shock; on 13th at 7.17 P. M. a strong shock, at 11.30 P. M. a feeble shock; on 14th at 3 A. M. and 12.48 P. M. feeble shocks; on 22d at 10 P. M. a strong shock; on 30th at 0.23 A. M. a feeble shock. At Cartago, twelve miles east of San José, five shocks occurred from 7 P. M of the 14th to 5 A. M. of the 15th.

Aug. 29. Letters from Alaska, dated Sept. 1, state that frequent shocks had occurred during the summer, in connection with renewed activity of the volcanoes of the Aleutian Islands. On Aug. 29, the village of Makuslin on Unalaska Island was destroyed by earthquake shocks and tidal waves.

Sept. 7. Three shocks from west to east at San Francisco about 9.35 A. M.—(U. S. Weather Rev.)

Sept. 24, 29. At San José, Costa Rica, feeble shocks at 5 A. M. and 6.55 P. M. of 24th, and at 7.45 A. M. and 7.15 P. M. of 29th.

Sept. 29th A shock about 6 P. M. at San Francisco and Oakland, Cal., from N.E. to S.W.

Oct. 2. At 6 P. M. a severe earthquake occurred in the southern part of San Salvador, Central America. The village of Jacuapa was nearly destroyed and much damage was done in neighboring places. The movement lasted over forty seconds and was from southwest to northeast. Eruptions were feared from the neighboring volcanoes, and advices a few days later report great activity in the volcanoes Izalco and Santa Ana.

————. The same day a slight shock was felt in Santiago de Cuba.—(U. S. Weather Rev.)

Oct. 4. At 2.30 A. M. a shock was felt along the Hudson River from Marlborough to Peekskill, N. Y., a distance of about twenty-five miles. It was sufficiently violent to awaken persons and at some places was accompanied by a rumbling noise. The direction was north to south.

Oct. 9. A severe earthquake at Manizales, the capital of Antioquia, United States of Columbia, destroyed over a hundred houses, including the church, hospital and city buildings.

Oct. 11. At San José, Costa Rica, a feeble shock at 5 P. M.

————. The same day at 7.30 P. M. a severe shock at San José, Cal., accompanied by a rumbling noise. The vibrations were north and south and lasted thirty seconds.—(U. S. Weather Rev.)

Oct. 21. At 5.40 P. M. two shocks from north to south at Sacramento, Cal.—(U. S. Weather Rev.)

Nov. 11. At 9.45 A. M. a slight shock from east to west at San Francisco.—(U. S. Weather Rev.)

Nov. 18. A shock was felt at St Louis, Cairo, Memphis, Little Rock and other places in the Mississippi Valley. The direction was generally north to south. The time was reported by the U. S. Signal Service observer at Cairo as $11^h\ 51^m\ 50^s$ P. M. He says, "a trembling was felt, lasting forty seconds, followed by a rocking motion from W.N.W. to E.S.E. lasting twenty seconds, and a second trembling lasting ten seconds." Another slight shock was felt at Cairo at 5.10 A. M. of the 19th, the direction of which was also W.N.W. to E.S.E.

Nov. 23. At Murphy, N. C., a slight shock at 10 A. M. from west to east, with a rumbling noise.—(U. S. Weather Rev.)

Princeton, N. J., Jan. 1, 1879.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Note on J. C. Draper's paper "On the presence of Dark Lines in the Solar Spectrum which correspond closely to the lines of the Spectrum of Oxygen."*—The paper above referred to appeared in the October number of this Journal. A cursory glance at it gives the impression that the methods had been carefully criticised beforehand, that the experiments had been made with minute accuracy and that the results were trustworthy; but closer examination of it raises most serious questions on all the points mentioned. Errors of method and of experiment appear which make it quite impossible to accept the conclusions reached. It is the purpose of this note to point out some of these.

In the first place the author throughout the paper confounds Ångström's scale numbers with wave lengths. Thus, for example, p. 257, he says, line 18, the photographs were "in sections of eighty to one hundred wave lengths," line 24, "each wave length being five millimeters in extent," and line 34, "each section of one hundred or more wave-lengths;" p.

258, line 24, "Error amounting to half a wave length could therefore exist in the position of a line, according as it fell on one side or the other of a figure on the scale expressing a wave length;" p. 259, line 18, one iron line "to every eleven wave lengths was used;" p. 261, line 18, no element gives "a line within two or three-tenths of a wave length of that position;" p. 264, line 16, "no other element furnishes a line which falls on the same wave length." In proof that he really means scale divisions, he gives a section of his chart on p. 259, and says, line 38, "On the first space below the line is the scale of wave lengths, each wave length being five millimeters in extent;" and p. 260, line 28, "in the eighteen wave lengths represented in the diagram." There are eighteen scale divisions in the diagram, each scale division being five millimeters long. Again, p. 264, referring to the coincidence of oxygen and solar lines in his table, he says, line 2, "in four, the difference is only five one-hundredths of a wave length; in twenty-two, ten one-hundredths of a wave length; in four, fifteen one-hundredths of a wave length; in eleven, twenty-one one-hundredths of a wave-length; and in the remainder, the greatest difference is only thirty-five one-hundredths of a wave length." Referring to the table, the four lines first mentioned are given as 3982·75, 4075·50, 4345·15 and 4483·80; the corresponding oxygen lines being given as 3982·70, 4075·45, 4345·20, and 4483·75. The difference is obviously five one hundredths of a scale division, not of a wave length. From the fact that this error runs through the entire paper, it would almost seem as if the author was not aware of the distinction between wave lengths and scale numbers. Using Ångström's scale he confuses wave lengths with ten millionths of a millimeter; whereas in the case of D for example, the wave length is nearly 6,000 times greater. If the author really means what he says, he asserts that the wave length of the mean ray of the spectrum is one two hundred and fifty-millionth of an inch instead of about one forty-thousandth, as we know it is.

Second, the author deems it of the greatest importance in the preparation of his solar photographs to use reflected rays exclusively; saying, p. 256, last line, "*at no time did the solar rays pass through glass;* all error that might arise during refraction was thus avoided." After this virtual condemnation of the use of refraction at all, he not only uses for comparison Ångström's wave lengths made with achromatic lenses and a refracting grating, constructing even his chart upon them as a basis, p. 258, line 7, "the values assigned to the wave lengths in this chart are those of Ångström;" but the very spectrum of oxygen by which the coincidences of the lines of this element with those of the sun spectrum were to be established, was photographed with glass prisms and achromatic lenses.

Third, the author states that the prisms with which the spectrum of oxygen was photographed were adjusted "to the minimum deviation of D′." Supposing D_1 to be meant, this precaution, which gives the appearance of extraordinary accuracy to the adjustment, is practically an impossibility with the apparatus employed. Minimum deviation of the D line as a whole could not under these circumstances be distinguished from that of either of its components, nor could that of D_1 be distinguished from that of D_2. Moreover, it is difficult to understand why he adjusts to minimum deviation for D′ and not for G, near which the work is to be done. Instead of D′, the line for which his apparatus was adjusted should have been chosen in the photographic portion of the spectrum, for example between G and H.

Fourth, on page 265, line 25, the author says that this "is a problem not to be solved by the comparison of two spectra of small dispersion." Hence it is a matter of some surprise to find that in getting his oxygen spectrum, he uses only "two flint glass prisms of 60°" and for objectives, "achromatics of ten inches focus." The bright line spectrum of oxygen taken by Henry Draper, which the author in this paper inferentially attacks, was made, as we find on examination, with a direct vision battery of nine prisms and an observing telescope of forty-two inches focal length. The original negatives taken with the latter apparatus, must consequently have been eight or nine times as long as the author's; and even these were none too large for the proper solution of the question.

Fifth, the author seems to have attempted to compare together a diffraction spectrum of the sun with a prismatic spectrum of oxygen. Such a comparison, by the method adopted is manifestly of no value. Owing to the irrationality of dispersion of various refractive media it is an extremely difficult thing to compare accurately two prismatic spectra of different kinds. But the matter rises to an absurdity when a comparison is attempted between a grating spectrum and a prism spectrum. The graphic method, employed to supplement the direct method, does not appear to help the comparison, since the author nowhere gives both coördinates to the curve constructed.

Sixth, it is more than questionable whether the measurements of the solar spectrum lines actually made by the author are capable of the accuracy he assigns to them. The values in his table of wave-lengths are given to one hundredth of a division of Ångström's scale. As the author says on page 257 that each division of this scale, which is one millimeter, was enlarged to five millimeters upon the paper scale on which the photographs were projected, to measure to one hundredth of a scale-division would require the measurements on the screen to be made to one-twentieth of a millimeter or the one five-hundredth of an inch, about; a degree of refinement highly improbable under these conditions. Moreover the accuracy of the results of such measurements is seriously impaired by the variation in the position of the lines on the screen, due to the fact that the large number of negatives (eight or nine apparently), required to give the whole photographic spectrum, must, unless special precaution was taken (of which there is no evidence), have been made with glass of different thicknesses. When projected in the lantern, this variation in thickness would necessitate a change in focus and so cause a change in the magnifying power. The smaller sizes of photographic glass vary in thickness from one to two millimeters. Consequently the displacement of the lines due to the difference of magnifying power arising from this cause would exceed considerably the limit of measurement, which, as above stated, was the one five-hundredth of an inch. But another and a more serious cause of inaccuracy must here be pointed out. From the data given by the author, it may readily be calculated that his original photographs of the oxygen spectrum, taken with two prisms of 60° and with lenses of ten inches focus, could not have been over half an inch long in the region from G to H. Since Ångström's chart from G to H is sixteen inches long, the author's spectrum would have to be magnified thirty-two times to make it the size of this. But as each millimeter of Ångström's scale was made five millimeters on the author's scale of measurement, the original negative as thrown on the screen must have been magnified one hundred and sixty diameters. Any one who has worked at all in spectrum photography, knows that it is utterly futile for purposes of measurement, to magnify a photograph taken under these circumstances, as much as this, since then the size of the silver grains becomes larger than the details of the picture. In the absence of any precise statement the reader has to make the calculation for himself; but the figures above given cannot be far astray.

Seventh, there is only an appearance of accuracy when the attempt is made to fix the position of the oxygen spectrum lines to hundredths of one of Ångström's scale divisions. The projection method by which the solar lines were measured, has already been proved inadequate. And as to the method of graphical interpolation, used as auxiliary to the lantern, it does not appear that as used by the author, it was capable of any such accuracy as that claimed. In constructing the curve, the iron lines are taken with Ångström's values for the wave-lengths; but these, though estimated to tenths were read only to whole divisions of the scale. Moreover, only forty-seven iron lines were used in all, or one to every eleven scale divisions; the reading being to one one-hundredth of a scale division, or 1,100 numbers to one iron line. Since the author measured no wave-lengths directly, he was obliged to construct a considerable "portion of the curve from the wave-lengths of oxygen and air lines already given by various authorities." These values were taken, page 258, from Watts' Index of Spectra. On referring to this book, the values are given only to the units place. And even then, discrepancies amounting to from three to five entire units, or from three hundred to five hundred times the author's limit, appear in the wave-length as given by the various authors relied on for the measurements employed in the paper before us.

Eighth, the author nowhere states the peculiar character of the lines in the oxygen spectrum and appears not to know that they have any. He has apparently taken it for granted that the lines of oxygen are intrinsically as sharp as the lines of the solar spectrum. But this, at least in many instances, is known not to be the case. Consequently it is quite impossible to measure the oxygen lines as accurately as the solar lines, and even these as has been shown cannot be measured to the accuracy which the author claims. Ångström himself admits that there may be an error of one-tenth of a division in his scale numbers.

It would seem sufficiently obvious from what has been said that the results given in this paper are entirely vitiated by the errors of method and of experiment which it contains. The author must not be confounded, because of the similarity of initials, with the distinguished investigator, Dr. J. W. Draper. G. F. B.

2. *On the Influence of Pressure on Chemical Action.*—BERTHELOT calls attention to the results of Pictet's experiments on the liquefaction of oxygen and hydrogen as illustrating his thermochemical views. The decomposition of potassium chlorate into oxygen and potassium chloride, as he has proved, is an exothermic reaction not limited by its inverse; hence it is not arrested by a pressure of 320 atmospheres. In fact the reaction $KClO_3=KCl+O_3$, according to Berthelot's measures, evolves at the ordinary temperature 11 calories. About 400°, the chlorate being melted and the chloride solid, this quantity can only be increased. The same is true of the action of potassium hydrate upon the formate, the reaction by which Pictet prepared his hydrogen; the gas continuing to be evolved even under a pressure of over 600 atmospheres. This reaction is also exothermic and not limited by its inverse; the transformation represented by the equation

$$KCHO_2+KOH=K_2CO_3+H_2$$

evolving at the ordinary temperature 18·4 calories. At 400° or 500° all the bodies being supposed melted, the heat evolved would not be altered; because the heats of fusion of known salts do not exceed four calories and the initial system has two melted molecules, the final system has only one. Exothermic reactions then continue whatever be the pressure; but it is probable that their velocity is changed and perhaps the temperature at which they take place.—*Ann. Chim. Phys.*, V, xv, 149, Oct., 1878. G. F. B.

3. *On the Specific Heat and the Heat of Fusion of Gallium.*—BERTHELOT has determined the specific heat and the heat of fusion of gallium from an ingot weighing 34 grams, placed in his hands by Lecoq de Boisbaudran. The specific heat of this metal was determined in the author's water calorimeter, by the usual methods. Two experiments, made, the one between 119° and 30° the other between 106° and 12·5°, gave as the specific heat of liquid gallium (the melting point being 30°, but the state of surfusion continuing to near zero) 0·0802. The specific heat of solid gallium between 23° and 12°, was found to be 0·079. If the latter measurements be made too near the fusing point, the value obtained is too high.

The heat of fusion of gallium was determined by introducing a crystal into the surfused metal. The whole crystallized at once, and evolved heat which was measured. At 13°, the mean value for a unit of weight was 19·11 gram-degrees, the number remaining sensibly the same between 30° and 0°, because of the close agreement of the two specific heats. Referred to the atomic weight, 69·9, the heat of fusion is 1·33 kilogram-degrees or calories. The close correspondence of the two specific heats of gallium taken at nearly the same temperature, is true also of mercury, lead, tin and bismuth. The atomic heat of gallium in the liquid state is $69{\cdot}9 \times 0{\cdot}0802 = 5{\cdot}59$; in the solid $69{\cdot}9 \times 0{\cdot}079 = 5{\cdot}52$.—*Ann. Chim. Phys.*, V, xv, 242, Oct., 1878. G. F. B.

4. *On the Occurrence of Ytterbia in Sipylite.*—The mineral called sipylite was described by MALLET as a new niobate, as occurring in Amherst county, Virginia, associated with allanite.* An analysis was made of it by Brown in his laboratory, who found that, among other things, it contained 28 per cent of earths supposed to be erbia and yttria in the ratio of 27 to 1. At the request of DELAFONTAINE, a portion of this mixture of earths was sent to him by Mallet. Its pale yellow color indicated to him the presence of terbia or philippia, if not of both. But the feebleness of its absorption spectrum, and the very weak rose color of its nitrate and oxalate led him to believe that if no error had been made in determining the atomic weight, a new metal was present. The quantity of material being too small to decide the question, he succeeded in separating some sipylite from some allanite in his possession. From this a pale yellow earth was obtained, the nitrate of which showed in the spectroscope small quantities of erbia and philippia. But the high atomic weight 127 or 128, taken together with the weakness of its spectrum, indicated that the earth was new. By several partial decompositions of the nitrate, a feebly colored base was obtained, having an atomic weight near 134, giving colorless salts, yielding a sulphate like that of yttria, and crystallizing easily, a formate crystallizing in mamillated masses, and a double sulphate with potassium easily soluble in a concentrated solution of potassium sulphate. While he was looking for a name for the new earth, the description of Marignac's ytterbia appeared, the characteristics of which accord so well with that of his new earth as to leave no doubt of their identity. The discrepancy in atomic weight will be settled by new determinations.—*C. R.*, lxxxvii, 933, Dec., 1878. G. F. B.

5. *Upon the development of Electricity as the equivalent of chemical processes.*—In this paper H. F. BRAUN discusses the equivalence of heat and work, and electricity developed by heat and work. Some of his conclusions bear directly upon the question of dynamo-electric machines. He proves that with electricity of high tension, the per cent of potential electric energy which is converted into work is less, the greater, under like conditions, the tension is: That heat never can be wholly converted into electricity;

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* This Journal, III, xiv, 397, Nov., 1877.

but only to the same degree to which it can be also converted into work.

If placing the three quantities in this order: (1) Electrical potential energy; (2) Mechanical work; (3) Heat. We have: 1 can be entirely transformed into 2 and into 3; 2 can be entirely changed into 3 but only partly into 1; 3 in general, can never be entirely transformed into 2 or into 1. The remainder of the paper contains the application of the foregoing laws to the theory of the Voltaic cell.—*Wiedeman's Ann. der Physik und Chemie*, 1878, No. 10, p. 182. J. T.

II. GEOLOGY AND MINERALOGY.

1. *The Lœss of Minnesota;* by N. H. WINCHELL. The following facts are taken from the Sixth Annual Report (for the year 1877) of the Geological and Natural History Survey of Minnesota, under Professor N. H. Winchell.—That the lœss deposit is the result of widespread diffusion of fresh water, at the time of the last Glacial epoch over those surfaces either drift-covered or not, which were not at the time affected by the glacier movement, is highly probable; but what the peculiar circumstances and causes of such gentle diffusion of nearly tranquil waters were, it is not yet possible satisfactorily to detail. The lœss is found in all parts of Ramsey County, but it varies in thickness and in composition. It is thin or wholly wanting in some rolling gravelly tracts, and is very thick in some confined valleys. It is sandy, or graduates downward into sand, in much of the northern part of the county, particularly in Rice Creek valley, and in some places in the bluffs of the Mississippi below St. Paul, and it is fine and somewhat clayey in the high and rolling clay tract in the eastern part of the county, particularly in the eastern part of New Canada. It forms a very fine soil for farm crops. It covers the bowlders and gravelly clay of the real drift. It fills some old valleys—indeed is always thicker in valleys than on the uplands. It is occasionally stratified and passes into sand below in places where agitated water was abundant enough to have moved such materials before the epoch of the loam. In other cases it is placed abruptly immediately over a coarse, gravelly or bowlder-bearing stratum.

In the southwestern corner of the State (Rock and Pipestone Counties) there is a gradual change from stony bowlder-clay to lœss, horizontally, in passing from the Coteau de Prairie (in Lyon and Murray Counties) southward to the Iowa State line. Exposures along the banks of creeks, and the digging of wells, make this plain. There is a gradual loss of bowlders, then of the small stones, then of gravel; and an equally gradual increase of the characteristic features of the lœss,—close, clayey consistency, crumbling in the air like slacking quicklime, and white limy concretions, in some cases the concretions which have been so often mentioned as a peculiarity of the lœss, are in the same deposit with small gravel stones of northern origin; and pieces of northern limestone. The drift clay, true northern bowlder clay, the product of glaciers, thus changes gradually into a true lœss, the product of aqueous agencies. While this indicates for that locality, at least, a merging of one force into the other, and the slowness of the change, through an interval of about fifty miles in a broad, level, open country, it perhaps gives the key to the events that occurred in other latitudes where the surface was more broken, and where the effects are more complicated by not having all the steps recorded. Just as in the older geological formations, wherever the series is complete, without sudden transitions, the history is best known, so in the history of the drift, where the effects change gradually, are the records of "lost" epochs, and these "beds of transition" need the closest scrutiny, being the only evidence of what transpired between formations which in other regions pass abruptly from one to the other. This here indicates that the age of the lœss was cotemporary with that of the bowlder clay in the Coteau de Prairie. There must be some explanation given for the coëxistence of these forces which spread the loam and those which brought the glacial dirft. In other words, if the loam, which is sometimes a laminated clay, be regarded as the equivalent in age of the fine laminated clays of the great lakes and of other high-water marks in the northwest, which have been referred to a distinct "epoch" by Dana and others (the Champlain), then that epoch was not subsequent in time to the Glacial epoch but cotemporary with it, and its phenomena differ from those of the last Glacial epoch because they have been studied at distant points where they are contrasted, and where the glacial winter operated differently. Where there is an immediate succession of superposition, that fact in the drift does not imply immediate succession in time any more than it does in the Silurian rocks, a fact which has been ignored many times; and hence have resulted a great many special histories and theories. The lœss, for instance, lies on the older drift clay all along the Mississippi valley, and has generally been taken to prove an immediate transition from the drift-epoch to the loam-epoch, when really a long period of time, involving forest growths and the slow on-coming of a Glacial epoch, intervened, the loam itself passing horizontally into the glacial deposits of that epoch.

So in Ramsey County the loam has been seen to follow by insensible gradations from a sand or even a fine gravel, the change here taking place perpendicularly. In this case the coarser deposit below was the result of more copious and more agitated water, as in the bluff-terraces below St. Paul, or in the washed materials in the western part of Reserve township, and the loam the result of the diminution and more quiet state of the same waters. Thus, if the waters which overspread and washed the old drift and formed the gravelly terraces of the Mississippi came from the ice-fields of a contemporary glacier lying further north, then the waters which spread the loam, a finer deposit, also came from the same source, operating a little later, and with diminished force.

2. *Systematic Geology of the 40th Parallel;* by CLARENCE KING.*—The following are citations from one of the chapters in this valuable volume; it is entitled "Résumé of Stratigraphical Geology," and gives some of the geological conclusions reached by the author.

In the 120,000 feet of sedimentary accumulations the grander divisions of Archæan or Azoic, Palæozoic, Mesozoic, and Cenozoic are distinctly outlined by divisional periods of marked unconformity. Considered as a whole, there is a noteworthy fullness in the geological column. None of the important stratigraphical time-divisions are wanting except those obscure intermediate deposits which in other countries lie between the base of the Cambrian and the summit of the crystalline Archæan series. From the first of Cambrian age to the present every important interval of time is recorded in the abundant gathering of sediments, which are with singular fullness characterized by appropriate and typical life-forms.

As in all other geological fields, the most important interruption of the continuity of deposit was at the close of the Archæan age, and the most striking difference between any two successive groups of rocks is that which characterizes the relations of the Archæan and the Palæozoic. With the exception of a few slates of supposed Huronian age, which the microscope shows to be richly charged with crystallites, all the non-eruptive Archæan rocks have passed from the original condition of detrital beds into sheets or bodies of distinctly crystallized material.

Not only are the Archæan exposures of such frequency over the Fortieth Parallel area as to insure a moderately complete knowledge of stratigraphical sequence and materials of the period, but also, owing to the relations which have been described with the overlying Palæozoic, I am able to reconstruct with considerable accuracy the topographical configuration of the Archæan surface. Supposing all the post-Archæan rocks to be removed, and considering what we now know of the whole area at the close of the Archæan age, the first prominent fact is, that coëxtensive with the greater part of the Cordilleras—that is, from longitude 104° westward as far as the Archæan exposures extend—was a great Archæan mountain system built up of at least two sets of nonconformable strata, referred to Laurentian and Huronian; the lower and older composed of granitoid gneisses chiefly made up of quartz and orthoclase, but carrying a little mica, sparing triclinic feldspars, and chlorite pseudomorphous after garnet and mica.

Over these, whether with actual conformity or not is undetermined, lies an enormous series of mica gneisses rich in quartz and biotite, orthoclase ordinarily exceeding plagioclase. The earlier aplitic gneisses and the later mica gneisses expose about 25,000 feet each of conformable beds.

* See the preceding number of this Journal, page 66.

A third group, nonconformable with the earliest aplitic series, the relations with the intermediate mica-gneiss series being unknown, consists of mica and hornblende schists passing upward into slates, quartzites, limestones, and dolomites. * * *

Upon grounds set forth in Section IV of Chapter II it is clear that the general topography prior to the deposition of the earliest Cambrian rocks was that of a great mountain system, displaying lofty ranges made of crumpled strata, enormous precipices, a result of mechanical dislocation, and, finally, a type of high mountain sculpture of such broad, smooth forms as to warrant the belief that subaërial erosion had never carved and furrowed the mountain flanks with the sharp ravines characteristic of modern mountain topography. East of the Rocky Mountains, in the geological province of the Great Plains, there are no Archæan outcrops; and when we consider the comparative thinness of the later sedimentary beds superposed over that region, the absence of outcropping Archæan masses piercing through the latter sediments is excellent proof that over that area Archæan mountain ranges did not exist. This is important as defining the Archæan Cordilleras within the limits of the modern Cordilleras, or, as is a more strictly correct view, the Archæan Cordilleras have determined not only the general area but much of the local detailed structure of the modern Cordilleras.

The topographical features of the present terrestrial surface are far less grand than the Archæan orography. The great Archæan precipices brought to light in Uinta and Wahsatch ranges are absolutely unparalleled in the topography of to-day. * * *

There is always a complete, sharp, unmistakable nonconformity between the crystalline Archæan topography and the superjacent sediments.

Considered as a whole, the Palæozoic series constituted a conformable body, laid down over the rugged Archæan mountain system. It first appears in the region of the Rocky Mountains with a total thickness of about a thousand feet, the strata surrounding and abutting against permanent Archæan islands, which, during the whole Palæozoic and Mesozoic, were lifted above the level of deposition. Throughout all Palæozoic time only 1,000 feet of strata accumulated over our part of the Rocky Mountains, and we get no glimpses of deeper hollows in which lower Cambrian beds might have been deposited. Passing westward, the series gradually thickens to 32,000 feet in the region of the Wahsatch and about 40,000 feet at the extreme western Palæozoic limit, longitude 117° 30′, where, from the evidences of shore-phenomena, and the non-continuation of the beds westward, we are warranted in assuming the Palæozoic coast. * * *

Viewed regardless of the age of the individual beds, the Palæozoic series can be divided by the character of their materials into four great groups. The first is a purely detrital Cambrian, which, although of comparatively fine sediments, in the presence of occasional conglomerates gives evidence of repeated subsidence.

The second group is the great limestone series, beginning with the Pogonip Cambrian limestone, and extending upward to the top of the Lower Coal Measures for 11,000 feet, only interrupted, in the horizon of the Lower Devonian, by a sheet, from 1,000 to 2,000 feet thick, of fine quartzitic detritus. This enormous group of 11,000 feet of limestone, characterized by abundant pelagic faunæ ranging from the Primordial to the top of the Lower Coal Measures, represents in general an age of deep seas. * * *

At the close of the deep-sea lime-period came a third great stratigraphical division of the Palæozoic — Weber quartzite — a body of pure siliceous detritus from 6,000 to 10,000 feet in thickness, characterized by conglomerates both in the near neighborhood of the granitic islands and close to the Nevada shore.

This is immediately succeeded by the fourth group or Upper Coal Measure limestone, a body about 2,000 feet thick of strictly pelagic material.

The whole Palæozoic, therefore, may be summed up as to its material as two periods of mechanical detritus, interrupted by one and followed by another period of deep-sea lime-formation. While in the conglomerates which appear in all the siliceous members of the series we have evidence of episodes of shallow waters, yet the occurrence of 13,000 feet of limestone indicates enormous intervals of the continued sway of profound ocean. * *

After the close of this great conformable Palæozoic deposition, wide-spread mechanical disturbance occurred, by which the land area west of the Nevada Palæozoic shore became depressed, while all the thickest part of the Palæozoic deposits from the Nevada shore eastward to and including the Wahsatch, rose above the ocean and became a land area. Between the new continent and the old one which went down to the west, there was a complete change of condition. The land became ocean; the ocean became land. In the rising of the Palæozoic, however, the elevation proceeded no farther eastward than the Wahsatch. East of that point, the Upper Carboniferous beds were still the undisturbed ocean-bottom; but instead of receiving sediments either from the destruction of organic life within the ocean area or from the distant continental sources to the west, the newly elevated land-mass, extending from the Wahsatch west to 117° 30′, became the area from which was derived the post-Carboniferous detritus to form the great Mesozoic series that, east of the Wahsatch, were laid down conformably upon the still submerged and still undisturbed Carboniferous.

Upon the western side of the new land-mass, the Archæan continent, having gone down, made a new ocean-bottom, and upon this immediately began to accumulate all the disintegration-products of the new land-mass which the westward draining rivers and the ocean waves were able to deliver. Throughout the Triassic and Jurassic periods the western ocean was accumulating its enormously thick group of conformable sediments upon an Archæan floor, while east of the Wahsatch, in the mediterranean ocean, the sediments of the Trias and Jura were accumulating conformably upon the Carboniferous; until, at the close of the Jurassic age, there had accumulated in the western sea 20,000 feet, and in the mediterranean sea 3,800 feet, of Triassic and Jurassic material.

The comparison of the Trias-Jura series, in these two separated seas, shows two things: first, that the western sea was very deep during the Trias; secondly, that the mediterranean was shallow during the Trias. * * *

At the close of the Jurassic age, the western ocean, with its original floor of Archæan ranges overlaid by twenty thousand feet or more of conformable Trias-Jura sediments, suffered abrupt orographical uplift, resulting in the formation of a series of sharp folds and elevating a portion of the ocean area, extending from the eastern shore outward and westward as far as the present west base of the Sierra Nevada, making an addition to the continent of 200 miles, the Sierra itself constituting the most western and most elevated of the newly formed mountain ranges. * * *

While this powerful dynamic action was taking place on the west side of the land area, there still remained, so far as upheaval, subsidence, or folding is concerned, a complete calm in the region east of the Wahsatch. The uppermost shaly members of the Jurassic from the Wahsatch out to Kansas are immediately conformably overlaid by the basal members of the Cretaceous. * * *

During Cretaceous time the mediterranean ocean stretched from the eastern base of the Wahsatch into Kansas; and over the entire bottom of that body of water, with the exception of a few Archæan islands, which were still, as they had been throughout the previous ages since the beginning of the Cambrian, lifted above the plane of deposition, a continuous conformable sheet of Cretaceous sediments was laid down. Its greatest thickness was against the western shore of the ocean, namely, against the eastern base of the Wahsatch, where conformably over the top of the Jurassic shales are about 12,000 feet of Cretaceous beds. Passing eastward, this series in the province of the Great Plains near the eastern base of the Rocky Mountain system has thinned to 4,500 or 5,000 feet, and in western Kansas it reaches its thinnest development as described by the Geological Survey of that State. * * *

Throughout the whole Cretaceous, below the top of the Fox Hill, the molluscan fossils are invariably marine, with the exception of certain intercalated groups of purely fresh-water shells near the region of the Wahsatch, which, from their position close to the Cretaceous ocean shore, are evidently the in-washings of a fluviatile fauna.

Regarded as a whole, the basal member is a single sheet of siliceous sediments and rounded conglomerates from 300 to 500 feet thick. Over this lies the great Colorado group, 2,000 feet thick in the west, 1,000 feet thick in the region of the Great Plains, made up chiefly of fine calcareous and argillaceous material, which toward the middle of the group is prominently formed of marles or limestones.

Above the horizon of the Colorado group, the Fox Hill and Laramie are essentially of sandstones, about 9,000 feet in thickness in the region of the Wahsatch, about 3,000 feet in the region of the Great Plains. At the very summit of the uppermost or Laramie group are found Dinosaurs. The fauna up to the base of the Laramie is strictly marine. The Laramie itself carries the remains of an estuarial or brackish-water life, associated with strictly Mesozoic Saurians. With the close of the Cretaceous the conformable series of marine and estuarial deposits east of the Wahsatch come to an end, and the last moments of deposition were immediately followed by one of the most important orographical movements of the whole Cordilleran history.

From the eastern base of the Rocky Mountains to the eastern base of the Wahsatch the whole region was thrown either into wide undulations or sharp folds. So great a range as the Uinta, with its distinct, broad, flat anticlinal, was made at this period. Relatively to the present basin of the Colorado, the whole chain of the Rocky Mountains was elevated so as to define a broad, shallow depression, which now includes the waters of Colorado River. Powerful and important as this orographical movement was, it failed to disturb the coast deposits of the Pacific in California; but from reasons already given it seems probable that the first definition of the Cascade Range was caused by its force. In the general geology of North America the most important result of this immediately post-Cretaceous orographical movement was the elevation of the whole interior of the continent and the complete extinction of the inter-American mediterranean ocean.

From the date of this movement no marine waters have ever invaded the middle Cordilleras, and the subsequent strata are all of lacustrine origin. The effect of this orographical movement was to leave that part of the Cordilleras which falls within our study with a free drainage to the sea, with the single exception of the basin of Colorado River, which, from its configuration, immediately became the receptacle of the vast fresh-water Ute Lake, within whose area accumulated the important Vermilion Creek group, the earliest of the fresh-water Eocene strata. Throughout the entire Eocene period the basin of Colorado River was the theatre of a series of four Eocene lakes, whose deposits — unconformable among themselves, as has already been described — amount in all to 10,000 feet; lacustrine rocks characterized from the bottom to the top by an abundant series of vertebrate life covering the whole lapse of Eocene time. The Eocene of the Fortieth Parallel region was a period of four lakes superposed, the unconformity of their deposits due to four orographical disturbances.

An important orographical movement took place at the close of the Eocene, by which the province of the northern Great Plains and a long, narrow tract of Washington Territory, Oregon, Nevada, and California, lying on the eastern base of the Sierra Nevada and the present Cascade Range, became depressed and received the drainage of the surrounding countries, forming two extended Miocene lakes. The deposits of the westernmost lake are chiefly the tuffs and rearranged ejecta of volcanic eruption. The deposits of the Plains are the simple detritus from the surrounding lands. The series on the west are over 4,000 feet thick; in the east they are not proved to be over 300 or 400 feet. Both contain abundant and typical Miocene vertebrate life.

The close of the Miocene was signalized by a powerful orographical movement over the area of the western Miocene lake, which threw the beds accumulated on its bottom into folds. Contemporaneously with this movement the Miocene lake of the east, by the subsidence of the surrounding country, increased so as to cover the province of the Great Plains.

The Pliocene opened, therefore, with two enormous lakes, one covering the basin country of Utah, Nevada, Idaho, and eastern Oregon; the other occupying the province of the Plains. The Pliocene deposits of the Plains lake are calcareous and sandy beds, which have no nonconformity in angle of dip with the underlying sheet of Miocene sediment, but which overlap it in every direction. The deposits of the great western lake are nonconformable with the Miocene and immensely overlap it to the east, doubling the area of Miocene sediment. Both of these Pliocene lakes — as do the Miocene — contain the remains of rich faunæ. The eastern lake received a maximum of about 2,000 feet of strata; the western lake has nowhere shown over 1,400 feet.

The close of the Pliocene was signalized by another orographical movement, which threw the sediments of the Great Plains lake into their inclined attitude, dipping 4,000 feet to the east and 7,000 feet to the south from the Fortieth Parallel region. This same orographical movement acted differently upon the sheet of sediments which covered the Pliocene lake of the Great Basin. Instead of tilting the entire lake, it broke in the middle, and the two sides were depressed from 1,000 to 2,000 feet thick, the shores faulting downward. The result of the post-Pliocene movement in the department of the Plains was to give thereafter a free drainage to the sea. The result in the area of the Great Basin was to leave two deep depressions, one at the western base of the Wahsatch, one at the base of the Sierra Nevada, which, in Quaternary times, received the abundant waters of the Glacial period and formed the two lakes that have already been described in the Quaternary chapter.

3. *An Elementary Geology, designed especially for the Interior States;* by E. B. ANDREWS, LL.D., of the Ohio Geological Corps, and late Professor in Marietta College. 283 pp. 8vo. Cincinnati, 1878. (Van Antwerp, Bragg & Co.)—In this little work on Elementary Geology, the author, as his preface remarks, has had especial reference to the Interior portion of the United States, exclusive of the Southern States. Many of the illustrations and facts are accordingly from the formations of the Mississippi Valley. It is still a general review of the science, presenting briefly facts

connected with Lithology and Dynamical Geology, and more fully Historical Geology. It is a popular work on the subject for the general reader and will be found a useful book for the young student. The volume is neatly printed.

4. *An Outline of General Geology, with copious References*, designed for the use of both General and Special students; by **Theo. B. Comstock**, B.Ag., B.S., in charge of the Department of Geology, Paleontology and Economic Geology in Cornell University. 82 pp. 8vo. Ithaca, N. Y. Printed for the author at the University Press. 1878.—This work is based by the author on the Syllabus of his lectures to the students of Cornell University. It is a brief synopsis of the various branches of general geology, presenting in a condensed way the principles and conclusions with many prominent facts. It is well fitted for use in connection with a course of lectures; and the geological student will also find it valuable as a means of reviewing the subject. The work contains a list of references to various geological publications, including treatises, periodicals, transactions of Societies and memoirs, to aid the student in extending his range of study.

5. *Die Glimmergruppe.* II Theil, von G. **Tschermak**.—The first part of Professor Tschermak's memoir on the Mica family has already been noticed in this Journal (xv, 150, Feburary, 1878), in that the results of his crystallographical and optical studies were given. To these he has now added a discussion of the chemical composition of the species as previously defined by him. His conclusions are based upon sixteen new analyses made with especial care to avoid the errors contained in many earlier analyses and in consequence of which most of them are rejected by him in his discussions. The following are the principal results adopted by him: (1.) **Biotites**: *Anomite*, composed of $Si_6Al_6K_4H_2O_{24}$ and $Si_6Mg_{12}O_{24}$ in ratios from 1:1 to 2:1; *Meroxene*, composed of $Si_6Al_6K_3H_3O_{24}$ and $Si_6Mg_{12}O_{24}$ in similar ratios. *Lepidomelane:* composition, $Si_6Al_6K_2H_4O_{24}(Si_6Fe_6K_2H_4O_{24})$ and $Si_6Mg_{12}O_{24}$ (2.) **Phlogopites**: *Phlogopite*, composition, $Si_6Al_6K_6O_{24}$, also $Si_{10}H_8O_{24}$ (with $Si_{10}O_8F_{24}$) and $Si_6Mg_{12}O_{24}$ often in the ratio 3 : 1 : 4; *Zinnwaldite* (Cryophyllite), composition $Si_6Al_6K_6O_{24}$ ($Si_6Al_6Li_6O_{24}$ $Si_6Fe_{12}O_{24}$ and $Si_{10}F_{24}O_8$ in the ratio 10:2:3. **Muscovites**: *Lepidolite*, composition $3Si_6Al_6K_6O_{24}(Si_6Al_6Li_6O_{24})$ and $Si_{10}O_8F_{24}$. *Muscovite* (Damourite), composition $Si_6Al_6K_2H_4O_{24}$ true muscovite, and also this same together with $Si_{10}H_8O_{24}$, in the ratio 3:1 (Phengite); *Paragonite*, composition $Si_6Al_6Na_2H_4O_{24}$. *Margarite*, $Si_4Al_8Ca_2H_4O_{24}$.—*Vienna Academy*, lxxviii, June, 1878.

III. BOTANY.

1. *On Plant-Distribution as a field for Geographical Research;* by W. T. **Thiselton-Dyer**, Assistant Director of the Royal Gardens, Kew, London. 1878, pp. 36, 8vo.—This is a lecture, delivered (we believe) at the Royal Institution, and published originally in the Proceedings of the Royal Geographical Society, Lon-

don. Its teaching is interesting and truly noteworthy. It tells how "Vegetation in any given spot maintains its own only by having solved the problem of existing in the best way under the given circumstances. Introduce a new competitor for a particular site that can solve the problem rather more closely, and the old occupant must needs give way." It intimates that this must have been so all along geological time, and under all changes of climate, land and sea. It pictures the great hosts of plants oscillating between the poles and the equator, their ranks thinning by "the friction attendant on their movement," which has extinguished perhaps whole battalions. It takes a general survey of the prominent characteristics of the great floras, northern, southern and tropical, and of their principal divisions. It brings prominently forward "the opinion that the northern hemisphere has always played the most important part in the evolution and distribution of new vegetable types; in other words, that a greater number of plants have migrated from the north to the south [meaning across the tropics] than in a reverse direction." That proposition (based on the temperate floras) is well sustained by obvious facts, and follows almost of course from the greater amount and longitudinal contiguity of northern lands, as Mr. Darwin has "suspected." But this may probably be limited to the extant vegetation and its nearer predecessors. If the paleontological botanists are at all correct in their ordinal determinations, the reverse might well have been the case at earlier periods, when Proteaceæ and Laurineæ abounded in northern temperate regions. It must needs have been so if there was for any long period a preponderance of southern land with northward extension.

A good part of the lecture—as rich in practical value as the remainder is in theoretical interest—recounts what geographical explorers have recently been doing for botany by collecting materials and information, indicates how very much is yet to be done in this way, how easy it is to collect and preserve botanical specimens, and what important services the "roving Englishman" and still more the desciplined explorer, may render to the botanical studies. A. G.

2. *Conspectus Floræ Europææ*, auctore C. F. Nyman. Orelso Sueciæ, 1878. I. *Ranunculaceæ—Pomaceæ.* pp. 240, 8vo.—This systematic catalogue of European plants, arranged in the Candollean order, with leading references, principal synonyms, and localities, supplies a desideratum, so far as it extends, and the second part, which will include the remaining *Polypetalæ*, is announced as in press. It is evidently a work of critical importance, and is well arranged. A. G.

3. *Botanical Necrology of* 1878.—An unusual number of botanists have deceased in the course of the past year. The first and the last names on the list are venerable.

Elias Magnus Fries, of Upsal, died February 8, 1878, in the eighty-fourth year of his age, a month after the hundredth anniversary of the death of Linnæus at that ancient University. He was born, as was Linnæus, in the south of Sweden, was educated at Lund, where he was early made demonstrator of Botany, and was translated to Upsal more than forty years ago, where he occupied the chair, not of Botany, but of Practical Economy, answering, we suppose, to Rural Economy. He was, nevertheless, the greatest Swedish botanist since Linnæus, and the last survivor of those whose teachers were taught by Linnæus. He began to publish on Phænogamous Botany in the year 1814, in which department he was high authority to the last; but soon took up Lichens and Fungi, in the latter of which his knowledge was unrivalled and his judgment wonderfully correct, considering that his studies were unaided by the compound microscope. His last work of any consequence was a new edition of his *Hymenomycetes Europæi*, of which he wrote the preface on his 81st birthday, August 15, 1874.

LUDWIG PFEIFFER, of Cassel, died at the beginning of the year, at the age of 72. He wrote on *Cacteæ*, and published a Synonymia Botanica.

ANDREW MURRAY, a writer to the signet at Edinburgh, where he was born, died January 10, 1878, at the age of 66. He was an entomologist more than a botanist; but he came up to London to become the acting Secretary of the Horticultural Society, and became learned in *Coniferæ*, publishing a volume on the Pines and Firs of Japan in 1863, and, later, various articles upon the *Coniferæ* of our Pacific Coast.

ANDREW BLOXAM, an English clergyman, one of the earliest of the critical investigators of *Rubus*,—a genus which perplexes European botanists,—died February 2, 1877, at the age of 76.

FRANÇOIS VINCENT RASPAIL, whose name has for many years past been associated with radical politics, was in earlier years a keen but eccentric botanist. His memoir on the Grasses, with a new classification, was published at Paris in the year 1825; his new system of Vegetable Physiology and Botany in 1837. He died at Arcueil, near Paris, January 6, 1877, at the age of 87.

SULPIZ KURZ, Curator of the Calcutta Herbarium, and an active botanist, died at Palo-Penang, January 15, 1878. Age and birth unknown to us; but he was a pupil of von Martius at Munich, and went early to Java, whence he was transferred to British India, and was a valuable explorer. His Forest Flora of British Burma, in two volumes, was published at Calcutta last year, about the time of the author's death.

M. DURIEU (de Maisonneuve), long the director of the Botanic Garden at Bordeaux, author of many botanical and vinicultural papers, and of the first (Cryptogamic) part of a Flora of Algeria, died at Bordeaux, Feb. 20, 1878, at the age of 82.

CHARLES PICKERING, M.D., who died in Boston on the 17th of March last, in the 73d year of his age, and to whose memory a tribute has already been paid in this Journal, must be counted among the botanists, although most of his life was devoted to zoology, anthropology, and cognate studies. His extensive work On the Geographical Distribution of Plants and Animals is a collection of materials for the study of the subject; and a bulky volume entitled Man's Record of his own Existence—the printing of which was in progress when the author died, and which is not yet published—is largely a record of changes in the habitat of plants effected under human agency, from B. C. 4491 down to recent times. It is a monument of wonderful industry.

MORITZ SEUBERT, Professor of Botany at Carlsruhe, author of a Flora of the Azores on Hochstetter's collections and notes, and of a monograph of *Elatineæ*, also of several monographs in the Flora Brasiliensis, died April 6, in the 60th year of his age.

THOMAS THOMSON, M.D., the well-known associate of Sir Joseph Hooker in Himalayan exploration, and in the Indian Flora, the explorer of Thibet, sometime Director of the Calcutta Botanic Garden,—a botanist whose career of high promise, was sadly cut short by ill health—died in London on the 18th of April last, at the age of 60. He was the son of the distinguished chemist Thomas Thomson, of Glasgow, where the lamented subject of this notice was born and educated.

GIOVANNI ZANARDINI, Professor of Botany at Venice, patriarch of Italian Phycologists, died, April 24, at the age of 74.

ROBERTO DE VISIANI, Professor of Botany in Padua for many years, author of a Flora Dalmatica, and of many interesting papers, died on the 4th of May, at the age of 77.

BARTHELEMY CHARLES DUMORTIER, of Tournai, Belgium—long eminent as a statesman as well as botanist (the leader of the clerical party in Belgium politics), and greatly esteemed as a man—died July 9, in his 82d year. His earliest papers bear the date of 1822; he published on *Hepaticæ* in 1831, and again in 1871. He published on Grasses in 1823 and again in 1868. He brought out a new and elaborate classification of fruits in 1835.

ELIAS BORSZCZOW (whose name we could not presume to pronounce), Professor of Botany and Director of the Botanic Garden of Kiew, in Southern Russia,—who in 1858 botanically explored the Aral-Caspian desert, and published a monograph of the plants yielding galbanum and assa-fœtida,—died on the 12th of May.

JAMES MCNAB, Curator of the Edinburgh Botanical Gardens, as was his father before him, sometime President of the Edinburgh Botanical Society, the most accomplished of cultivators, and a well-informed botanist, died on the 20th of November, in his 69th year. We well remember his visit to the United States in the year 1834.

STEPHEN T. OLNEY, of Providence, Rhode Island, died July 27, 1878, at the age of 66. He was for many years one of the most active local botanists of this country; published in 1845 a Catalogue of Rhode Island Plants, with continuations and emendations in 1846 and 1847; a List of Rhode Island Algæ in 1871; in the latter years of botanical activity studied Carices with critical care and minuteness, published several fascicles of Exsiccatæ, admirably prepared; and formed a fine and rich herbarium and library, which he gave to Brown University. To it also, or at least to his native State, he made handsome legacies for botanical instruction, as well as other benevolent bequests. These benefactions, and his many good offices, should preserve a pleasant memory of a useful life, the end of which was obscured and afflicted by mental trouble. In Botany his name is commemorated by a remarkable Leguminous tree of Arizona (*Olneya*) and by several species of his own discovery. Mr. Olney was unmarried, and was for most of his life engaged in business, at first in Augusta, Georgia, and afterward in his native town.

JAMES WATSON ROBBINS, M.D., died at Uxbridge, Massachusetts (where he resided and was an esteemed physician for the greater part of a long life), on the 9th day of January, 1879, at the age of 77. With the exception of Dr. Bigelow he was the oldest New England botanist, and perhaps the oldest in the United States; and, within his range, he was certainly one of the most careful and accurate. He was a colleague of William Oakes, who had the pleasure of naming several species discovered by him in his honor, and he had an extended correspondence with all our botanists. He collected not only throughout New England, but in Virginia and Maryland, where he resided for several years when a young man, and on the shore of Lake Superior, where he spent four years. Of late, he devoted his attention mainly to aquatic phænogamous plants, especially to the difficult genus *Potamogeton*. He contributed the monograph of this genus to the last edition of Gray's Manual. He first detected that simplest and smallest of flowering plants, *Wolffia*, in this country. His excellence and amiability secured the attachment of all who knew him. He was born at Colebrook, Conn., November 18, 1801, graduated at Yale College in 1822, and there took his medical degree in 1828. In his death we have lost the most critical student of the botany of New England and the Northern Atlantic States.

JACOB BIGELOW, the most venerable of botanists, even more distinguished as a physician, a cultivator of the fine and useful arts, and a scholar, one of the most rounded and symmetrically developed men of his time and place, died at Boston, on the 10th of January ult. The notice due to his life and services must be deferred to the next number. A. G.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Technologisches Wörterbuch;* I. Deutsch-Englisch-Französisch; bearbeitet von E. ALTHANS, L. BACH, u. A., herausgegeben von Carl von Albert, mit einem Vorwort von Dr. Karl Karmarsch. Dritte verbesserte und bedeutend vermehrte Auflage. 743 pp. 8vo. Wiesbaden, 1877. (J. F. Bergmann; B. Westermann & Co. in New York.)—This Technological Dictionary deserves high commendation both for its completeness and its accuracy. The subjects which it embraces include all the prominent branches as well of pure as of applied science, so that the work is alike valu-

able to the student and the manufacturer, the technologist and the merchant. This volume gives the English and French equivalents of the German technical and scientific words and expressions; the other two volumes of the series are arranged for English and French readers respectively. The names of seventeen specialists are given, who have assisted in the preparation of this the third edition of the first volume, and they alone are a sufficient proof of the excellence of the work.

2. *Chromometry.*—Under this name Professor Kœnig describes a new branch of quantitative analysis with the blowpipe. The method depends upon the observations of the color produced in the borax bead by various metallic oxides, with the "Chromometer"; in the hands of the describer it is made to yield very accurate results.—*Amer. Soc. Philadelphia*, Oct. 4, 1878.

3. *Additional characters of the Sauropoda;* by O. C. MARSH.—Beside the characters of the *Sauropoda*, already made known by the writer,* others of importance have been since brought to light.

The skull, of which so little has been known hitherto in the Dinosaurs, presents in *Morosaurus grandis* some strongly lacertian characters. It is short, high and narrow, something like that of the Chameleon. The supra-occipital is very large, and forms the upper part of the foramen magnum. The ex-occipitals have long par-occipital processes. The occipital condyle is formed entirely of the basi-occipital. The long basipterygoid processes are of the lacertian type. The quadrate is elongated, very slender above, and has a small articular head. Below, it is fixed by the pterygoid, which unites with it by suture. On the outer side of the quadrate, below the middle, the quadrato-jugal joins it by suture. Its posterior end is cup-shaped, with the cavity opening outward, and partially closed by a thumb-like process. This bone divides in front, one branch going upward, and the other forward, to join the jugal and complete the lower arch. The bones of the cranium were united by open sutures, and there are large parietal fossæ. The orbits are large, and there is a vacuity in front of the lachrymal. The upper jaws are especially short and deep, and each maxillary contained nine teeth. The nasals and premaxillaries were narrow. The lower jaws were not coössified at the symphysis, and each dentary bore twelve teeth. This bone was very deep in front, and pointed behind.

Episternal bone.—A bone, found with the remains of *Apatosaurus ajax*, so strongly resembles the episternal element in lizards, that it must be regarded as an episternal bone. It is cruciform in shape, and symmetrically bilateral. The posterior process is abruptly truncated; the anterior is short and obtuse, and the lateral processes are the longest. The lower surface of this bone is slightly convex on the median line, and more strongly convex transversely. The upper surface and sides indicate that it was surrounded mainly by cartilage. By this interpretation of the bone, the posterior truncated process abutted against the sternum, the posterior reëntrant angles were met by the coracoids, or the intervening cartilage. This would leave the anterior concavities for clavicles, no evidence of which has hitherto been found in Dinosaurs. Their existence in *Apatosaurus*, if not in other *Sauropoda*, seems therefore a necessity. The large rugose facet on the anterior projection of the scapula offers the natural place for union with that bone. No clavicles were found with this episternal bone, but a single specimen from a neighboring locality agrees closely with what we should expect the corresponding clavicle to be. These interesting remains will be more fully described by the writer in another communication.

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* This Journal, vol. xvi, p. 411, and vol. xvii, p. 85.

Yale College, January 22, 1879.

4. *Portrait of Humboldt.*—An excellent portrait, of natural size, painted by Steuben, belongs to Madame de Schœnfeld, of Paris, and is to be disposed of. It should be in some of the Galleries or Museums of this country. Information respecting it may be sought of the distinguished botanist, E. Cosson, 7 Rue Abbatucci, Paris.

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[THIRD SERIES.]

ART. XXI.—*On the Variability of the Ultimate Molecule;* by Professor W. A. NORTON.

I PROPOSE, in the present article, to adduce numerous facts which seem to afford decisive evidence that the ultimate molecules of bodies, under varying conditions of pressure and other relations to surrounding molecules, are subject to change in the intensities of the forces of attraction or repulsion they are capable of exerting, at a given distance, on such contiguous molecules; while retaining the same temperature and the same chemical constitution.

The first evidence I shall present that the ultimate molecule may, under certain conditions, experience a change in the intensities of its active forces, is derived from the *facts and phenomena of the set, or permanent distortion of materials*, which remains after they have been temporarily subjected to a force of stress.

Numerous series of experiments have been made by Fairbairn, Hodgkinson, Chevandier and Wertheim, Morin, and other experimenters, the writer included, with the view of determining the amount of set experienced by various materials, after a certain fraction of the breaking load has been applied and withdrawn; and of ascertaining all the laws of the set, under varying loads, variations in the duration of stress, varying conditions in the application of repeated stresses, etc. The following are some of the principal facts and laws that have been experimentally determined.

(1.) If a bar of any material (e. g. wood, iron, or steel) be subjected to varying forces of stress—whether tensile, compressive, or transverse—increasing progressively from a small fraction of the breaking load, on the removal of the load a certain set will remain, which will increase steadily with the amount of the load. The progressively increasing set will be proportional to a power of the load which varies, more or less, from one material to another, and for the same material with the ratio of the load to the breaking weight. The law of variation falls, in general, between the first and fourth power of the load; but when the stress is a large fraction of the breaking load, the set may increase according to a much more rapid law. This is strikingly true of wrought iron.

(2.) There is, strictly speaking, no definite limit of elasticity, that is, no minimum limit of the load below which no set results. This fact was decisively made out by Hodgkinson in his experiments on the behavior of wrought iron under a tensile stress, by Chevandier and Wertheim in their extensive course of experiments on numerous varieties of wood, variously strained, and in the writer's experiments on the set, or residual deflection, of bars of wood, iron and steel, after a transverse stress. In the last mentioned series of experimental determinations, a perceptible set was obtained, with each material, immediately after the stress was removed, however small its amount, until it fell below the lowest possible determination of which the apparatus was capable (viz: $\frac{1}{10000}$ of an inch); and on increasing the delicacy of the measuring apparatus it was found that the least perceptible immediate set was still limited only by the capability of detecting, with the apparatus, minute displacements.

We may say, then, that every load, however small, gives rise to an immediate set;* and that the set increases progressively with the load, however small the increments of load may be, up to the point of rupture. If for any ordinary material, there is a limiting load below which no immediate set results, such limit has not yet been determined.

(3.) The set augments with the duration of the stress, up to a certain interval of time. When moderate strains are applied it has been found that this limiting interval may vary, with the strain, from a few minutes to one hour. In experiments with white pine subjected to a transverse stress, a set from five to nine times greater was obtained by prolonging the stress.

(4.) The amount of the set does not remain invariably the same for an indefinite time after the stress is withdrawn, but is subject to material fluctuations. If very small it may pass off entirely in a few minutes. Otherwise, after decreasing for a short interval of time (from 5m. to 20m., in the author's experiments) it increases for a longer interval. This increase of set is eventually succeeded by another decrease; which may again be followed by other smaller fluctuations extending over several hours. As a final result the set subsides entirely, or settles into a permanent value; according to the amount and duration of the stress applied.

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* By immediate set is meant that which obtains immediately after the stress is withdrawn.

These facts lead unmistakably to the conclusion that the molecules of the materials experimented on, as a result of the temporary application of the force of stress, experienced an abiding change of dimensions or mechanical condition, by reason of which the intensities of their mutual actions no longer remained the same at the same distance, as before the stress was temporarily applied, and hence did not return precisely to their former configuration or relative positions; also that this molecular change increased progressively with the amount of the stress, and, to a certain extent, with the prolongation of the stress; and that the disturbed molecules, in acquiring their new mechanical condition, fluctuated more or less to the one side and the other of the final state of equilibrium. To make this more evident, let us consider somewhat in detail the results of a single series of experiments; for example, those made by Captain Rodman (U. S. Army) on a cylinder of cast iron, 35 inches long and 1·366 inches in diameter, subjected to a tensile stress. The smallest set observed was $\frac{1}{714000}$ of the length, and resulted from the temporary application of a tensile stress of 6,000 pounds to the square inch. This stress, temporarily applied, had then the effect to produce an abiding increase of $\frac{1}{714000}$ in the distance between two contiguous molecules in the line of stress. Loads increasing by 1,000 pounds, from 6,000 pounds to 25,000 pounds per square inch, were successively applied at considerable intervals of time, and the resulting sets, or permanent elongations, increased progressively from $\frac{1}{714000}$ to $\frac{1}{8000}$ of the length; and accordingly the distance between contiguous molecules in the line of stress were augmented by the same fractional amounts. The direct operation of these loads, before being withdrawn, augmented the molecular distances by fractional amounts varying from $\frac{1}{3700}$ to $\frac{1}{385}$. Now this bar of cast iron was a mass of molecules which, whenever no external stress was in actual operation, must have been in equilibrium under the operation of antagonistic forces of attraction and repulsion exerted by the molecules, and yet as the result of a temporary application of a series of increasing loads, twenty in number, it took up a series of as many different configurations, in which the distance between contiguous molecules in the line of stress augmented progressively from $\frac{1}{714000}$ to $\frac{1}{8000}$; and this although the actual displacements produced by the suspended loads were only from

$\frac{1}{3700}$ to $\frac{1}{385}$. To suppose that these molecules, during all these progressive permanent changes of mutual distance, continued to exert forces of mutual action varying only with the distance, is to suppose that they were capable of taking, under the operation of such forces, constant at the same distance, an indefinite series of positions of equilibrium differing from each other by exceedingly minute fractions of the distances between the molecules. The absurdity of this supposition is still more apparent when we consider that we must also admit that the molecules were capable of being in equilibrium, in relative positions which it required at the outset certain forces of stress to bring them into, although the inherent molecular forces are not supposed to have changed. Without violating fundamental principles of Statics, we cannot escape from the conclusion that the molecules must have undergone some change, under the operation of the temporary strains developed within the bar by the external stress, by reason of which they exerted mutual actions that had no longer the same intensity, at the same distance, as before the stress was applied. To suppose that the bar was not homogeneous throughout, would here be of no avail, for whatever its inequalities of constitution or texture, at all points of its mass the equilibrium must obtain under the operation of the inherent forces of the molecules there present, whether like or unlike. Besides the fact of a progressive increase of set, by minute degrees, while the stress augments by small fractions of the breaking load, is found to hold good whether the body is in the condition of cast iron, or wrought iron, or wood (a material that has resulted from a natural growth). This statement also disposes of the conjectural explanation of the phenomena of set which has sometimes been given, that they are attributable to a relief of the particles of the body from internal strains subsisting before the stress is applied. For, if it were possible to form any distinct conception of such internal strains that could give rise to such phenomena, it is idle to suppose that all varieties of material, and all the diverse specimens of the same material, are habitually in similar states of internal strain. On the other hand, if we admit that the molecules may be susceptible of variation in their mechanical condition, under the influence of their mutual, effective attractions, or repulsions, when forced out of their relative positions of equilibrium, and that a fraction of this molecular change may abide after the external stress is withdrawn, we have a simple, general explanation of the phenomena of set, and a satisfactory basis for a definite theory of imperfect elasticity. A body which is imperfectly elastic under a certain external force of stress, would be simply one whose molecules experience a sensible permanent change of mechanical condition as the result of the operation of this force of stress. When the load is removed the body should then have a certain set.

We may add here, incidentally, that all facts and phenomena in which imperfect elasticity plays any part (e. g. the properties of ductility, malleability and plasticity), are so many additional evidences of variations occurring in the mechanical state of the molecule.

A second general evidence that the ultimate molecule is liable to variation, may be derived from the observed changes in the mechanical properties of materials produced by tension, pressure, heat, etc. Thus the enacity of iron may be greatly increased by wire-drawing, also by hammering and rolling when heated. This is generally explained by saying that the particles have been brought into new relative positions; though the effect in the latter case is attributed in part to the removal of impurities. Such an explanation is little better than a statement of the fact that a change of configuration has occurred, and the tenacity has in consequence increased. It neither states what the change of configuration is, nor why it is possible while the inherent forces of the molecules are supposed to remain the same, nor why it should be attended with an increase of tenacity.

The tenacity of bar iron may also be materially increased by the process of thermo-tension. This consists in subjecting the bar to a large tensile stress, while heated to about 400° F., and then allowing it to cool after being relieved of strain. The tenacity of good bar iron may be increased from 12 to 20 per cent by this process. At the same time the bar has become permanently elongated by about 6 per cent. The precise amount of the effect varies with the temperature to which the bar is raised, and the intensity of the tensile stress applied. Shall we assume, then, that the molecules, while retaining the same forces, have taken up an indefinite series of positions of equilibrium, varying progressively with the number of degrees of temperature and the number of pounds of stress, or admit at once that under the varying conditions of temperature and stress, permanent variations in the intensities of their active forces must have taken place, and thus new configurations have become possible, attended with augmentations of tenacity. In all such cases it must be borne in mind that the displacements of the molecules are but small fractions of the distances between them.

We will add that the well-known effects of tempering and annealing, also give intimations of permanent changes effected by variations of temperature in the mechanical condition of the individual molecules.

Let it not be understood that in what precedes, the intention has been to convey the idea that the molecular displacements produced by wire-drawing and hammering, and the permanent changes of mechanical properties that may result from the operation for a time of a force of tension, or pressure, or a change of temperature, must be, in every instance, wholly ascribed to variations of molecular condition; but that such variations must play an important part in the mechanical processes of change, and constitute one mechanical feature of the substances thus specially affected.

Another evidence that the ultimate molecule has the property of variability, is furnished by the great change of mechanical properties that sometimes results from the presence in a body of minute quantities of other substances (e. g., the great changes in the tenacity and other properties of steel, attendant on slight variations in the percentage of carbon associated with the iron; and in the tenacity of iron or steel resulting from slight differences in the percentage of manganese, phosphorus, etc.) According to the results of the experiments of Kirkaldy on Fagersta steel (Sweden), the union of 0·5 per cent (or $\frac{1}{200}$) of carbon with the iron augmented the tenacity of the hammered bars from $\frac{1}{3}$ to $\frac{1}{5}$, and an increase in the quantity of carbon from 0·5 per cent to 1 per cent (from $\frac{1}{200}$ to $\frac{1}{100}$) augmented the tenacity from $\frac{1}{3}$ to $\frac{1}{5}$. The presence of $\frac{1}{200}$ by weight of carbon, would give only one chemical molecule of carbon for every forty-three chemical molecules of iron; and of $\frac{1}{100}$, only one molecule of carbon to every twenty-one molecules of iron. The following table, extracted from the Article on Steel, in Johnson's Cyclopedia, by Mr. A. L. Holley, gives the comparative effects on the mechanical qualities of steel of several different proportions of carbon.

Fagersta (Sweden).			**Neuburg (Austria).**		
Quantity of Carbon.	**Av. Breaking Load.**	**Per centage of Stretching.**	**Quantity of Carbon.**	**Av. Breaking Load.**	**Per centage of Stretching.**
	lbs. per sq. in.			lbs. per sq. in.	
1·00 p. c.	126, 486 to 146, 383	2 to 6 p. c.	0·88 to 1·12	126, 486 to 149, 226	5 p. c.
0·70 p. c.	100, 905 to 130, 750	4 to 6 p. c.	0·62 to 0·88	103, 747 to 126, 486	5 to 10 p. c.
0·45 p. c.	99, 404 to 103, 747	9 to 10 p. c.	0·38 to 0·62	80, 298 to 103,747	10 to 20 p. c.
0·35 p. c.	68, 217 to 69, 638	12 p. c.	0·15 to 0·38	68, 217 to 80, 298	20 to 25 p. c.
0·30 p. c.	59, 690 to 62, 533	11 to 22 p. c.	0·05 to 0·15	56, 848 to 68, 217	25 to 30 p. c.

It will be seen that with the Fagersta steel an increase in the proportion of carbon from 0·30 of 1 per cent to 1 per cent (or $\frac{1}{143}$) more than doubled the tenacity; and that with the Neuburg steel an increase in the proportion of carbon from 0·15 per cent to 1·12 per cent (or about $\frac{1}{100}$) augmented the tenacity in the ratio of 2½ to 1.

It has been shown by recent experiments* that an increase in the percentage of manganese in Bessemer steel from 0·5 per cent to 1 per cent, while the percentage of carbon and phosphorus remain the same, may augment the tenacity of the steel, when untempered, by one-fifth, and when tempered in oil by one-quarter. In this case but one molecule of manganese is added to every two hundred molecules of iron.

The magnitude of these variations of tenacity is greatly disproportionate to the quantity of carbon, or manganese, associated with the iron. Nor can such mechanical effects, increasing progressively with the percentage of the ingredient, be reasonably attributed to continued variations in the number of atoms in the physical molecules, or in the configurations of unvarying molecules. It would seem that their possibility, on physical grounds, can only be conceived by admitting that the iron molecules, which combine with the carbon molecules, suffer in consequence some physical change by reason of which the intensities of their attractive actions on surrounding molecules are increased, and that these molecular changes extend, by propagation from one molecule to another, throughout the entire mass.

Additional intimations that the ultimate molecule has the property of variability, are furnished by certain facts in *Chemical Physics.*

(1.) In solution, solids assume the mechanical properties of liquids. The entire mass of the solution is in the liquid state, and, to all appearance, the molecules of the dissolved solid are as truly in the liquid condition as those of the solvent. The molecules of the solid have not suffered any change of chemical composition. The natural inference then is, that they have experienced a change of mechanical condition. The alternative supposition is that the physical molecules of the solid are more complex than the chemical molecules, and in the process of solution are broken up into others less complex, which, in their association, have the mechanical properties of a liquid.

(2.) Certain elementary substances have the property of *Allotropy*, that is of assuming, under varying circumstances, different states or forms in which they exhibit very different physical and chemical properties. Sulphur, phosphorus, oxygen, and carbon, may be cited as conspicuous examples. "Several other elements are known to be capable of existing in two or more allotropic states. Indeed, instances of allotropy are so common that some chemists have been led to believe that most, if not all, of the elements may exist in distinct allotropic states." In some cases (e. g., sulphur, phosphorus and carbon) the substances occur in different states of solidification—crystalline, vitreous, or amorphous—that is, their molecules occupy different relative positions of equilibrium. Now the capability of taking up these different positions is an intimation of a probable difference in the mechanical condition of the ultimate molecules. "Diversity of crystalline structure, or its entire absence, is, however, evidently only one of the many differences of properties incidental to allotropism; in many cases it must be regarded as a consequence of the latter, by no means its cause. At all events the cases of allotropism which occur among the gases, cannot be explained by this theory" (i. e., by a mere difference of molecular arrangement.) The diverse chemical properties generally exhibited in the different allotropic states of a substance must apparently be attributable to diversities in the condition of the individual molecules; and so be regarded as evidence in support of the doctrine of the variability of molecules. In fact Berzelius suggested the term allotropism as expressive of the idea that the diversities of property observed might depend on some absolute difference of quality in the different varieties of a substance, and not upon any dissimilarity in the arrangement or number of its molecules; and we are told "that this idea has ever since steadily gained favor, although directly opposed to the doctrine of the immutability of matter, one of the principal tenets on which the chemistry of the first half of the century was based."

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* On the Effects of Phosphorus and Manganese on the Mechanical Properties of Steel; by M. Euverte (Van Nostrand's Engineering Magazine, April, 1878, p. 363, etc.).

While in allotropism we have the significant fact that the same element can exhibit the properties of two different substances, we have in *isomerism* a kindred fact,—that the same substances combined in precisely the same proportions may form two or more compounds differing widely from each other in their chemical and physical properties. Whatever may be the supposed differences of molecular arrangement in these varying compounds, such differences must apparently find their efficient cause in varied mechanical and physical states assumed by the individual molecules of the constituent substances. That varying circumstances of combination should suffice to determine all the supposed diversities of arrangement of molecules, while the combining "chemical atoms" retain the same intensity of mutual action, seems in the highest degree improbable. In many, if not all the cases of isomerism, there must apparently be a true allotropy, or change of state of the ultimate molecule of the different elements combined.

In corroboration of the evidence of the variability of molecules furnished by allotropism and isomerism, we may mention that "many well known substances exhibit differences in hardness, color, specific gravity, solubility, etc., according to the circumstances in which they are produced."

(3.) Some substances in the *nascent state* exhibit chemical properties, which they do not possess, or, if at all, only in an inferior degree, in the ordinary free state. Thus oxygen, hydrogen, and nitrogen, are much more active, chemically, in the nascent than in the free state. We must then suppose that the chemical molecules either differ in these two states, in the number of their constituent atoms, or in the physical and mechanical condition on which their chemical activities depend, without any difference in the number of constituent atoms. The former supposition involves the improbable hypothesis that the same atoms regarded as endued with inherent forces of a constant intensity, may take up two or more different relative positions of equilibrium.

The citation of facts, mechanical, physical, and chemical, which furnish evidence that the ultimate molecule is liable to variation, might be extended almost indefinitely. In fact, in every change of state which a body may experience, and in almost every change of physical relation to other substances, the active forces exerted by the molecules on one another are different in intensity—though the temperature remain the same; and, in general, after the body has been subjected to any mechanical process, the molecules manifest different intensities of mutual action. Many physical processes are attended with similar results. Some of these variations of molecular condition have been conjecturally explained by the vague hypothesis that the particles are differently arranged—either that the existing molecules, regarded as groups of kindred atoms, take on different configurations, or become broken up and replaced by others. But others are of such a character that this explanation is wholly inadmissible (see p. 185); and, in general, no definite theory is offered of a mechanical process by which such supposed changes in the constitution of the molecules may be brought about.

If, in view of the array of evidence that has now been presented, it be admitted that the ultimate molecule has the property of variability, in the sense that has been defined, under varying mechanical relations to other molecules, and the molecule be regarded merely as a group of kindred atoms, then we must conclude that *these atoms are also variable*, after the same manner as the molecule itself. For it is obvious that a group of kindred atoms cannot exercise an external action varying in intensity at a given distance, and increasing progressively with the amount of change experienced in its mechanical relations to surrounding molecules, if the inherent atomic forces suffer no change. But to suppose that the inherent atomic forces vary in intensity at a given distance, is to discard the ordinary conception of the atom, which is that it is not only invariable in its mass and volume, but also in the intensity of action, whether attractive or repulsive, it is capable of exerting on another atom at a given distance from it. We are accordingly constrained to regard the elementary parts of molecules, which have received the designation of atoms ("chemical atoms") as in reality liable to variation in their capabilities of mechanical action. But we are not therefore under the necessity of rejecting the fundamental idea of invariable atoms, for we may instead regard the "chemical atom" as consisting of a true atom of ordinary matter invested with an ethereal atmosphere, and thus as being an organized mechanical system, that may be capable of variation in its dimensions and force of external action at the unit of distance, with varying external relations—though the inherent forces of all the atoms in the system remain unchanged. This is the general conception of the "chemical atom" which I have adopted in my papers on Molecular Physics.* Upon this view the chemical atom, and the molecule (chemical or physical) have the same general constitution, and differ only in the precise mechanical state of the ethereal atmosphere that invests the atom proper. To this last element of bodies, incapable of change in its mass as measured by its weight, I have given the designation of the *ultimate molecule.* The mutual actions of ultimate molecules constitute the *molecular forces;* and so include, taken in the most comprehensive sense, the mutual actions of ultimate molecules in the different state answering to the "chemical atom," "chemical molecule," and "physical molecule." Upon this hypothesis, with regard to the constitution of the chemical atom and molecule, it is the investiture of the atom proper with an ethereal atmosphere that has armed it with the power of operating on adjacent atoms; and, at the same time, imparted to it its properties with respect to the physical agents of light, heat and electricity. The definite conception I have formed of the constitution of this ethereal atmosphere, is not that it is simply a mass of luminiferous ether condensed around the atom. Such an atmosphere, perfectly elastic, would be incapable of permanent change as a consequence of temporary variations of external pressure. Besides, while researches in Physical Optics have led to the conclusion that the atoms of bodies are probably surrounded by such atmospheres, electric phenomena give intimation of the presence in bodies, and in intimate association with their molecules, of a subtile fluid termed the "electric fluid," or ether. It has been shown by physicists that certain of these phenomena do not absolutely require the admission of an ether distinct from the luminiferous, but the same cannot be said of electric phenomena in general. Moreover, all the efforts hitherto made to explain electric phenomena by hypothetical motions of the atoms of bodies, have proved futile. No definite physical theory of electricity has been framed that does not involve the conception of a subtile electric fluid, the atoms of which repel each other, and are attracted by those of ordinary bodies; and we have as yet no sufficient reason for abandoning the original hypothesis that this fluid is distinct from the luminiferous ether. If, then, there be an electric ether distinct from the luminiferous and presumably less subtile (i. e. made up of larger atoms) the ethereal atmosphere condensed around an atom by its attractive action, should consist of an atmosphere of luminiferous ether and an *envelope* of electric ether immersed within this for a certain depth. Such is the definite conception I have adopted of the constitution of the molecular atmosphere. It may be characterized as an ethereo-electric atmosphere. From this combined with the fundamental hypothesis that recurring impulses are incessantly exerted on one another, by all the atoms, ethereal and non-ethereal, that make up the ultimate molecule, I have deduced the operation of certain molecular forces. The two ethers condensed around the atoms, and pervading the interstices between them, are constituted as media capable of transmitting wave actions, by the permanent statical repulsion exerted between their atoms. The recurring impulses just mentioned originate such wave actions which are propagated from one molecule to another. The attractive impulses exerted by the central atom of a molecule on its electric envelope, originate in it waves that take effect attractively on contiguous molecules. On the other hand, the repulsive impulses exerted by the atoms of the envelope on each other, originate waves that take effect repulsively on these molecules. In considering the action of one molecule on another contiguous to it, the virtual center of the first system of waves will be somewhat without the inner surface of the envelope, and that of the other system somewhat within its outer surface—both centers being on the line of the centers of the two molecules. It is farther to be observed, that the subsidences of the envelope, induced by the attractive impulses from the central nucleus, should originate waves in the dense luminiferous ether, posited below the envelope, which would be propagated indefinitely outward and take effect on the contiguous molecule as repulsive pulses. But this system of wave-actions may be combined with the attractive system into resultant attractive actions. The different sets of waves, emanating from different virtual centers, will be propagated according to the law of inverse squares. The *effective* action of one molecule on a contiguous one will be the difference between the resultant attractive action just mentioned, and the opposing action of the system of repulsive waves first mentioned. The following is the general expression for this *force of effective molecular action.**

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* This Journal, July, 1864, and May, 1872.

$$f=\frac{n(3r^2+2rx)}{(r+x)^2(2r+x)^2}-\frac{m}{x^2}, \tag{1}$$

in which x denotes the distance between the molecular envelopes, r the distance between the center of the system of repulsive waves first mentioned and that of the system of attractive waves, n the coëfficient of attraction, and m that of repulsion. If we put $x=ur$, $\frac{n}{m}=k$, and $\frac{m}{r^2}=p$, this expression becomes

$$f=\left(\frac{k(3+2u)}{(1+u)^2(2+u)^2}-\frac{1}{u^2}\right)p. \tag{2}$$

The first term represents the attractive action, the other the repulsive. I propose, in a subsequent paper, to apply to this physical formula numerous quantitative and qualitative tests.†

From the point of view taken in the present discussion the important question here arises, whether the ultimate molecule as it has been defined, endued with the forces of external action just specified, is susceptible of permanent variation, and if so, how? It is, in fact, not difficult to see that it may be subject to variation in its dimensions, and in the coëfficients (n and m) of its attractive and repulsive wave impulses, under variations of pressure. Suppose that the external pressure is increased, and the ultimate molecules are thus urged nearer to each other, the molecular envelopes will in consequence be compressed, and the dimensions of the molecules, as well as their coëfficients of attraction and repulsion be altered. When the compressing force is withdrawn, if the dense luminiferous ether posited between the envelopes and the central atoms of the ultimate molecules has been merely compressed without any diminution of its quantity, the envelopes should return to their original position, and the coëfficients of attractive and repulsive wave actions to their original value, and the molecules would return to their original relative positions; but in fact a portion of this dense ether will be urged outward between the atoms of the envelopes, and so when the recoil comes on, the envelopes may fail to reach their original distance from the central atoms. The dimensions of the molecules, as a whole, may thus be permanently diminished, and, in consequence, the distance between the centers of contiguous molecules at which the opposing molecular actions counterbalance each other be permanently less. The coëfficients n and m (eq. 1) should also be more or less altered, and thus the neutral distance x between the contiguous envelopes at which the effective force f becomes zero, should vary. From the combined operation of these two causes, the relative positions of equilibrium of the molecules should be more or less altered. If a force of tension be applied to the body, a permanent change of an opposite character may ensue.

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* See this Journal, July, 1864, p. 68, and May, 1872, p. 338.

† A paper embodying the principal results obtained in the application of the tests here referred to, was read before the National Academy of Sciences at the meeting in April last.

It still remains to be seen how far the molecular theory that has been set forth, can be reconciled with chemical facts. This question opens too wide a field for present discussion even in the most cursory manner, but a word or two ought to be said to obviate the objection that may at once occur to the reader as fatal to the theory, viz: that the absolute invariability of atoms is established by chemical facts. Strictly speaking, these facts only show the weight of the atoms to be invariable, and that they exhibit the same chemical properties whenever the relations to other atoms are the same, and also in certain cases (e. g. solution) over a certain range of variation in such relations; provided, also, the operation of the physical agents on them is the same. But this does not preclude the supposition that large variations of their mechanical state may occur while the atoms are under different mechanical and physical relations. It may be added that the received molecular formulas of substances would still remain the same, but would have a different physical interpretation. The hypothesis of the breaking up of complex molecules and the formation of new ones, would be replaced by the simple conception of the contraction or expansion of molecular envelopes, with attendant variations of the volume of the mass, and in the physical and chemical properties of the ultimate molecules, which now play the part of "chemical atoms." In gaseous compounds the number of atoms specified in the molecular formula of the compound, would represent the proportionate degree of condensation of the gaseous mixture. Thus, when two volumes of hydrogen are mixed with one volume of oxygen, and by the electric spark are made to combine, the mixed gases would be condensed, by reason of a condensation of all the molecular envelopes, and thus a diminution in the size of the effective molecules, into a space two-thirds that occupied by the mixture before the combination. The elementary volume of the mass would contain two ultimate molecules ("chemical atoms") of hydrogen, and one of oxygen, just as the "molecular volume," in the received chemical theory, contains these atoms.

If we contemplate this general conception of chemical phenomena, deducible from our general molecular theory, simply in the light of a representative scheme, it must be admitted to be far simpler than the received theory; which is, for the most part, only a scheme of hypothetical transformations supposed to be in some inexplicable way effected by a force of "affinity" or "chemism." For it regards the molecule and "chemical atom" as having a similar physical constitution, and attributes all changes of chemical properties occurring in such molecules to contractions or expansions of their ethereal envelopes, and attendant variations in their active forces, under the operation of the molecular forces and physical agents. If it should hereafter be made apparent that the mechanical relations of *dissimilar* ultimate molecules may in fact be such that changes in the dimensions and effective forces of the molecules may supervene, and that a special force of attraction may come into operation when two such molecules come into juxtaposition, it will be seen that a rational basis is offered for a physical theory of chemical phenomena.

Yale College, Oct. 25, 1878.

ART. XXII.—*Möbius on Eozoon Canadense;** by J. W. DAWSON, LL.D., F.R.S.

Eozoon Canadense has, since the first announcement of its discovery by Logan in 1859, attracted much attention, and has been very thoroughly investigated and discussed, and at present its organic character is generally admitted. Still its claims are ever and anon disputed, and as fast as one opponent is disposed of, another appears. This is in great part due to the fact that so few scientific men are in a position fully to appreciate the evidence respecting it. Geologists and mineralogists look upon it with suspicion, partly on account of the great age and crystalline structure of the rocks in which it occurs, partly because it is associated with the protean and disputed mineral Serpentine, which some regard as eruptive, some as metamorphic, some as pseudomorphic, while few have had enough experience to enable them to understand the difference between those serpentines which occur in limestones, and in such relations as to prove their contemporaneous deposition, and those which may have resulted from the hydration of olivine or similar changes. Only a few also have learned that *Eozoon* is only sometimes associated with serpentine, but that it occurs also mineralized with loganite, pyroxene, dolomite, or even earthy limestone, though the serpentinous specimens have attracted the most attention, owing to their beauty and abundance in certain localities. The biologists on the other hand, even those who are somewhat familiar wtth foraminiferal organisms, are little acquainted with the appearance of these when mineralized with silicates, traversed with minute mineral veins, faulted, crushed and partly defaced, as is the case with most specimens of *Eozoon*. Nor are they willing to admit the possibility that these ancient organisms may have presented a much more generalized and less definite structure than their modern successors. Worse, perhaps, than all these, is the circumstance that dealers and injudicious amateurs have intervened, and have circulated specimens of *Eozoon*, in which the structure is too imperfectly preserved to admit of its recognition, or even mere fragments of serpentinous limestone, without any structure whatever. I have seen in the collections of dealers and even in public museums, specimens labelled "*Eozoon Canadense*" which have as little claim to that designation as a chip of limestone has to be called a coral or a crinoid.

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* Der Bau des Eozoon Canadense, von Karl Möbius, Professor der Zoologie in Kiel. Palæontographica, Band xxv.

The memoir of Professor Möbius affords illustrations of some of these difficulties in the study of *Eozoon*. Professor Möbius is a zoologist, a good microscopist, fairly acquainted with modern foraminifera, and a conscientious observer; but he has had no means of knowing the geological relations and mode of occurrence of *Eozoon*, and he has had access merely to a limited number of specimens mineralized with serpentine. These he has elaborately studied, and has made careful drawings of portions of their structures, and has described these with some degree of accuracy; and his memoir has been profusely illustrated with figures on a large scale. This, and the fact of the memoir appearing where it does, convey the impression of an exhaustive study of the subject, and since the conclusion is adverse to the organic character of *Eozoon*, this paper may be expected, in the opinion of many not fully acquainted with the evidence, to be regarded as a final decision against its animal nature. Yet, however commendable the researches of Möbius may be, when viewed as the studies of a naturalist desirous of satisfying himself on the evidence of the material he may have at command, they furnish only another illustration of partial and imperfect investigation, quite unreliable as a verdict on the questions in hand. The following considerations will serve to indicate the weak points of the memoir.

1. A number of errors and omissions arise from want of study of the fossil *in situ*, and from want of acquaintance with

its various states of preservation. Trivial errors of this kind are his referring to my photograph in Plate III, of the "Dawn of Life," as if it were natural size, and his stating that the larger specimens have fifty laminæ, whereas they often have more than an hundred. More important is his failing to appreciate aright the occurrence of *Eozoon* in certain layers of regularly bedded limestones, the rounded or club-shaped forms of the more perfect specimens, the manner in which the layers become confluent at the edges of the forms, as described by Sir W. E. Logan and myself, or the amount of crushing and fracture which most of the specimens exhibit. Thus he fails to convey any adequate idea of the Stromatoporoid forms and mode of occurrence of the organism, or indeed of its general character and probable mode of growth. Farther he treats it from the first as a mere laminated aggregate of calcite and serpentine, without reference to its occurrence in any other state, and also without reference to the fragmental limestones in part made up of its remains. He objects strongly to the want of definiteness of form and distribution in the chambers and connecting passages, without making allowance for defects of preservation, or mentioning the similar want of defined form in some *Stromatoporæ*. He admits, however, that the modern *Carpenteria* and its allies are in some respects equally indefinite. He farther objects to the impossibility of detecting regular primary chambers like those in modern foraminifera, but seems not to be aware that, as I have recently shown, some *Stromatoporæ* originate in a vesicular, irregular mass of cells, and that in *Loftusia*, both the Eocene *L. Persica*, and the Carboniferous *L. Columbiana*, the primary chamber is represented by a merely cancellated nucleus.*

2. With reference to the finely tubulated proper wall of Eozoon, he has fallen into an error scarcely excusable in an observer of his experience, except on the plea of insufficient access to specimens. He confounds the proper wall with the chrysotile veins traversing many of the specimens, and obviously more recent than the bodies whose fissures they fill. That he does so is apparent from his stating that the proper-wall structure sometimes crosses the bands of serpentine and calcite, and also that it presents a series of parallel four-sided prisms, whereas, when at all perfectly preserved, it shows a series of cylindrical threads penetrating a calcite wall. That some of his specimens have contained the proper wall fairly preserved is obvious from his own figures, in which it is possible to recognize both this structure and chrysotile veins, though confounded by him under the same designation. He objects, somewhat naïvely, that many of the chambers fail to exhibit

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* See Journal of London Geol. Soc., January, 1878.

this nummuline wall, and that it sometimes presents a ragged appearance or is altogether opaque. In point of fact it can appear distinctly, either in decalcified specimens or in slices, only when the minute tubes are filled with some substance optically distinguishable from calcite, or not acted on by dilute acid. When the proper wall is merely calcareous (and I have specimens showing that it is often in this state, and without any serpentine in its pores), its structure is ordinarily invisible, and it is the same when the calcareous skeleton has from any cause lost its transparency or has been replaced by some other mineral substance. Even in thickish slices, the tubes, though filled with serpentine, may be so piled on one another as to be indistinct. All this may be seen in Tertiary *Nummulites.* When wholly calcareous their tubulation is often quite invisible, and when imperfectly injected with glauconite or other silicates, they often present a very irregular appearance. If Professor Möbius will study the Nummulites injected with glauconite from Kempten,* Bavaria, in addition to the casts of *Polystomella* from the Ægean to which he refers, he will be better able to appreciate these points. It may be worth repeating here that, in examining the original specimens of Eozoon, I did not recognize the proper wall. I did not doubt that it must have existed in some form, since I could easily detect the canals in the supplemental skeleton; but I did not wonder at its non-appearance, knowing the chances against its preservation in a recognizable form. Its discovery was due to the subsequent investigations of Dr. Carpenter.†

3. To the canal system, Professor Möbius does more justice, and admits its great resemblance to the forms of this structure in modern *Foraminifera.* This indeed appears from his own figures, as will be seen from the fac-simile tracings reproduced here, figs. 1, 2, 3 and 4, which well show how wonderfully this structure has been preserved, and how nearly it resembles the similar parts of modern *Foraminifera.* He thinks, however, that these round and regularly branching forms are rather exceptional, which is a mistake; though it is true that the sections of the larger canals are often somewhat flattened, and that they become flat where they branch. They are also sometimes altered by the vicinity of veinlets or fractures, or by minute mineral segregations in the surrounding calcite, accidents to which all similar structures in fossils are liable. Another

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*I am indebted to Dr. Otto Hahn for specimens of these most interesting fossils.

† It may deserve mention here that the Carboniferous *Fusulina* very rarely shows its tubulated wall, and that Dr. Carpenter had maintained its Nummuline affinities before he obtained specimens showing this particular structure. Structures so delicate as these are indeed only preserved exceptionally in fossil specimens.

objection, not original with him, is derived from their unequal dimensions. It is true that they are very unequal in size, but there is some definiteness about this. They are larger in the thicker and earlier formed layers, smaller or even wanting in the thinner and more superficial. In some slices the thicker trunks only are preserved, the slender branches having been filled with dolomite or calcite. It is difficult, also, to obtain, in any slice or any surface, the whole of a group of canals.* Farther, as I have shown, the thick canals sometimes give off groups of very minute tubes from their sides, so that the coarser and finer canals appear intermixed. These appearances are by no means at variance with what we know in other organic structures. Another objection is taken to the direction of the canals, as not being transverse to the laminæ but oblique. This, however, may be dismissed, since Möbius has of course to admit that it is not unusual in modern *Foraminifera*. It may be added that some of the appearances which puzzled Möbius, and which are represented in his figures, evidently arise from fractures displacing parts of groups of canals, and from the apparently sudden truncation of these at points where the serpentine filling gives place to calcite. It would also have been well if he had studied the canal systems of those *Stromatoporæ* which have a secondary or supplemental skeleton, as *Cœnostroma* and *Caunopora*. In illustration of this I give in fig. 5 a group of these canals from a recent paper of my own.†

4. A fatal defect in the mode of treatment pursued by Möbius is that he regards each of the structures separately, and does not sufficiently consider their cumulative force when taken together. In this aspect, the case of *Eozoon* may be presented thus: (1.) It occurs in certain layers of widely distributed limestones, evidently of aqueous origin, and on other grounds presumably organic. (2.) Its general form, lamination and chambers, resemble those of the Silurian *Stromatopora* and its allies, and of such modern sessile foraminifera as *Carpenteria* and *Polytrema*. (3.) It shows under the microscope a tubulated proper wall similar to that of the Nummulites, though of even finer texture. (4.) It shows also in the thicker layers a secondary or supplemental skeleton with canals. (5.) These forms appear more or less perfectly in specimens mineralized with very different substances. (6.) The structures of *Eozoon* are of such generalized character as might be expected in a very early Protozoan. (7.) It has been found in various parts of the world under very similar forms, and in beds approximately of the same geological horizon. (8.) It may be

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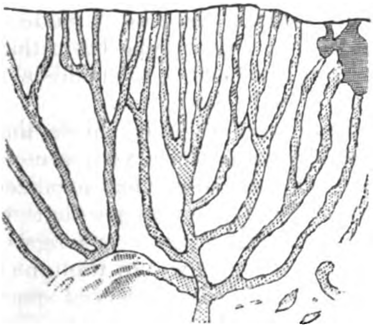
* I have succeeded best in this by etching the surface of broken specimens.

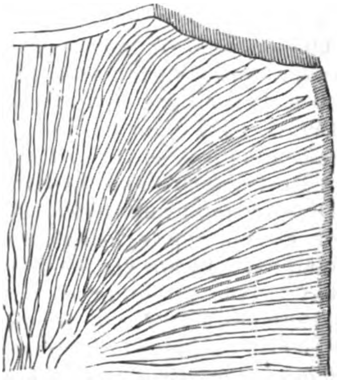
† Journal of London Geological Society, January, 1878.

1.



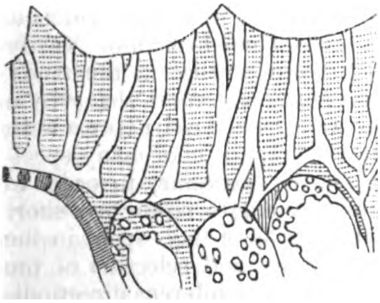
Canals of *Eozoon* (after Möbius).

2.



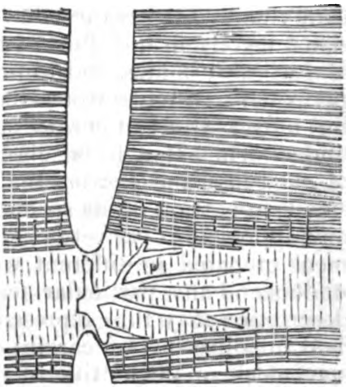
Finer canals of *Eozoon* (after Möbius).

3.



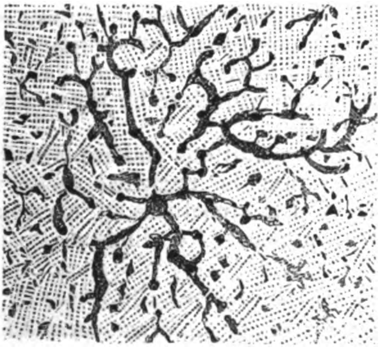
Canals of modern *Calcarina* (after Möbius).

4.



Canals and Tubule of Tertiary *Nummulina* (after Möbius).

5.



Canals of *Cœnostema*—Upper Silurian—(original).

added, though perhaps not as an argument, that the discovery of *Eozoon* affords a rational mode of explaining the immense development of limestones in the Laurentian age; and on the other hand that the various attempts which have been made to account for the structures of *Eozoon* on other hypotheses than that of organic origin have not been satisfactory to chemists or mineralogists, as Dr. Hunt has very well shown.

Professor Möbius, in summing up the evidence, hints that Dr. Carpenter and myself have leaned to a subjective treatment of *Eozoon*, representing its structure in a somewhat idealized manner. In answer to this it is necessary only to say that we have given photographs, nature-prints and camera tracings of specimens actually in our possession. We have not thought it desirable to figure the most imperfect or badly preserved specimens, though we have taken pains to explain the nature and causes of such defects. Of course, when attempts at restoration have been made, these must be taken as to some extent conjectural; but so far as these have been attempted they have consisted merely in the effort to eliminate the accidental conditions of fossilized bodies, and to present the organism in its original perfection. Such restorations are not to be taken as evidence, but only as illustrations to enable the facts to be more easily understood. It is to be observed, however, that in the study of such fossils as *Eozoon*, the observer must expect that only a small proportion of his specimens will show the structures with any approach to perfection, and that comparison of many specimens prepared in different ways may be necessary in order to understand any particular feature. A single figure or a short description may thus represent the results of days spent in the field in collecting, of careful examination and selection of the specimens, of the cutting of many slices in different directions, and of much study of these with different powers and modes of illumination. My own collection contains hundreds of preparations of *Eozoon*, each of which represents perhaps hours of labor and study, and each of which throws some light more or less important on some feature of structure. The results of labor of this kind are unfortunately very liable to be regarded as subjective rather than objective by those who arrive at conclusions in easier ways.

Taken with the above cautions and explanations, the memoir of Professor Möbius may be regarded as an interesting and useful illustration of the structures of Eozoon, though from a point of view somewhat too limited to be wholly satisfactory.

ART. XXIII.—*The Magnetic Storm of May* 14, 1878, *observed in North America.*

[Communicated by Carlile P. Patterson, Superintendent United States Coast and Geodetic Survey.]

THE extensive magnetic disturbance of May 14, 1878, of which accounts have been given in Nature,* and which was observed in China, Australia and England, also made its record in North America at our magnetic observatory, established at Madison, Wisconsin, in the winter of 1876–1877. This observatory is in latitude 43° 04′ 29″·5, and in longitude $5^{h}\ 57^{m}\ 36^{s}\cdot 5$ west of Greenwich; in it are mounted a set of Brooke's Magnetographs, and daily photographic traces of the changes in magnetic declination and in the horizontal and vertical forces have been produced since March, 1877, and are intended to be kept up for some years. The declination traces for several days preceding the 14th were normal, but about midnight May 13–14, a series of disturbances commenced consisting in part of some large oscillations to the eastward and westward, and in part of a great number of small and rapid oscillations. The characteristic features of the trace may be given as follows:

	Madison mean time. d. h. m.	Greenwich mean time. d. h. m.
The disturbance in *declination* commenced about	14 0 00 A. M.	14 5 58 A. M.
A principal westerly† extreme reached	1 05 "	7 03 "
A principal easterly extreme reached	2 36 "	8 34 "

Range of motion 16′·5; after this a series of smaller oscillations continue to past noon.

	d. h. m.	d. h. m.
A maximum westerly position is reached about	0 16 P. M.	6 14 P. M.
And an easterly extreme at	0 53 "	6 51 "
Extreme westerly deflection at	3 26 "	9 24 "
A sharp motion to the eastward commences at	5 40 "	11 38 "
A principal easterly extreme reached at	6 24 "	15 0 22 A. M.

Range of motion of principal disturbance 31′·7.

There is also a westerly extreme about	7 10 "	1 08 "
And an easterly extreme about	9 16 "	3 14 "

After 10 P. M. the irregularities gradually subside.

Last extreme easterly position	15 1 10 A. M.	7 08 "

It will be noticed that at the Greenwich observatory the storm commenced on May 14, at $6^{h}\ 05^{m}$ A. M., at Stonyhurst observatory at $6^{h}\ 04^{m}$, at Zi-ka-wei, near Changhai, also at $6^{h}\ 04^{m}$ (Gr. time), and at Melbourne supposed at $6^{h}\ 20^{m}$; the storm may therefore be taken as simultaneous at these places. At

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* Vol. xviii, Nos. 467, 468, 469.

† Referring to north end of the magnet.

Greenwich the north end of the needle moved eastward between 6 and 9 A. M., but at Madison the general motion was westerly; again the sharp deflection commencing at 5^h 40^m Mad. time (11^h 38^m P. M. Gr. time) was to the *eastward* at Madison, and to the westward after 11^h 45^m at Greenwich, thus deflecting the magnets in opposite directions.

The northern component of the *horizontal* force was sharply affected at Madison, the force diminishing at 14^d 0^h 05^m A. M., Madison time, 14^d 6^h 03^m A. M., Greenwich time. The disturbance continued, but between 2½ and 7½ A. M., the trace is too indistinct to be read; the small oscillations continue to about 11^h 45^m, when they become superseded by a series of larger waves culminating in a maximum extreme at 2^h 30^m P. M., Madison time, 8^h 28^m P. M., Greenwich time, and a minimum at 3^h 58^m P. M., Madison time, 9^h 56^m P. M., Greenwich time. The large disturbances continue till about 10^h 20^m P. M., having reached a maximum extreme about 4^h 50^m P. M., Madison time, 10^h 48^m P. M., Greenwich time, and a minimum extreme at 9^h 03^m P. M., Madison time; 15^d 3^h 01^m A. M., Greenwich time. Range between maximum at 2^h 30^m, and minimum at 9^h 03^m, $\frac{1}{131}$ of the horizontal force, nearly. In the Greenwich account it is stated "the first start in the trace of the declination magnet at 18^h 05^m (Astr. Rec.) is most distinct." Now within two minutes of this time occurs the first and sharpest deflection in our horizontal force trace at Madison, thus marking distinctly the commencement and simultaneousness of the storm.

The disturbance in the *vertical* force commenced about May 14, 1^h 10^m A. M. (7^h 08^m Gr. time), and terminated about 3^h 30^m A.M.; between this time and 5^h 45^m P. M., the trace was smooth, but between 5^h 45^m and 6^h 45^m a sharp deflection took place in the opposite direction, the maximum force occurring at 6^h 11^m P.M. (May 15, 0^h 09^m A. M. Gr. time), the deflection or increase amounted to $\frac{1}{525}$ of the vertical force. The vertical force trace did not exhibit any of the tremulous motion noticed in the other two curves.

I may state that a description of the Madison magnetic observatory, together with the discussion of the first year's observations and results, is nearly ready in manuscript for publication.

CHAS. A. SCHOTT,

Assistant C. and G. S. in charge Observatory.

Coast Survey Office, Washington, D. C., Jan. 6, 1879.

ART. XXIV.—*On the Flocculation of Particles, and its Physical and Technical Bearings;* by EUGENE W. HILGARD, of the University of California.

I HAVE heretofore (this Journal, Oct. and Nov., 1873) discussed, casually rather than directly, the tendency of small particles to form, under the influence of a moderate agitation, granular aggregates or compound particles of larger size, opposing to mechanical disintegration more or less resistance, according to the circumstances of temperature and moisture. Some discussions since made, and more especially that of Professor S. W. Johnson, on the Mechanical Effects of Tillage,* appear to me to render desirable a more detailed consideration of the various bearings of this phenomenon, which, despite its simplicity, and obviousness in every-day life, seems not to have received all the attention it deserves. This is strikingly exemplified in the modes of experimentation and the more or less contradictory results obtained by different observers—Von Klenze, Haberlandt, Ad. Mayer, Nessler, and others who have studied the capillary relations of soils to water. In comparing the effects of "packing" and "loosening" of powders and soils upon their relations to water, it makes a material difference whether the material used was dry, damp or wet, and whether or not the soil had been previously under tillage for some length of time. Again, Johnson seems to incline to attribute to the flocculation of the *clay* in soils, by various agencies, effects which, I think, clearly belong to all small particles as such.

Perhaps the best fundamental experiment (which can be neatly projected on a screen by the beam of a magic lantern) is the one described in my previous paper (loc. cit., p. 290). A sediment consisting of granules of the uniform hydraulic value of 1^{mm} per second, is introduced into an ordinary conic-cylindrical elutriating tube, placed vertically, in which the current of water entering at the small orifice below, alone performs the stirring-up needed to keep the sediment from settling down. If now a current of water be turned on, corresponding to a velocity *below* that of 1^{mm} at the mouth of the tube, of course none of the sediment can pass out of the upper end, but it will be kept circulating in the conical portion, by a current going upward in the axis of the tube, and downward on the sloping sides of the cone. If this be kept up for ten or fifteen minutes, and then the velocity gradually increased, it will be found that scarcely any of the sediment will pass off, either at the velocity corresponding to its true hydraulic value, or even at one four or five times higher; the cause being that its single grains have coalesced or "flocculated" into compound grains of from five to thirty or more of the original ones, thus forming in effect a very coarse sediment of roundish masses. When these are allowed to settle, it will be seen that this altered sediment occupies a very much larger space than did the original single-grain sediment, in consequence of the large vacant spaces left between the aggregate-grains; the relation between the two being somewhat like that between gunpowder dust and coarse blasting powder.

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* Rep. Conn. Exp. Station for 1877.

If now the coarse sediment be violently stirred by shaking up, or if it be boiled even lightly, the heavy masses disappear, the water becomes uniformly turbid, and after the proper time of quiescence, a thin horizontal layer of single-grain sediment is formed at the bottom of the vessel.

There is nothing very remarkable or new in this experiment; every chemist knows the phenomena it exhibits from every-day experience, and acts upon it in the gentle stirring given to liquids in which precipitates just forming are desired to flocculate. Every geologist has seen the flocculent aggregate-granules rolled along the bottom by a depositing current, and has noticed the rapid clearing of the gentle stream after it has been rendered turbid by stirring; while quiescent pools *in the same material* have remained turbid for some length of time. The experiment with the elutriator-tube, however, is well adapted to the demonstration of the following laws governing the formation of aggregates of immersed particles:

1. The tendency to flocculation is roughly in inverse ratio to the size of the particles. I have already stated (loc. cit., p. 291) that with quartz grains it practically ceases when their diameter exceeds about $0{\cdot}2^{mm}$, or 8^{mm} hydraulic value. It goes without saying that the number of particles that may cohere into one mass, follows substantially the same law. Sediment of $0{\cdot}25^{mm}$ hydraulic value, will sometimes form large masses, like snow flakes, on the sides of the elutriator-tube.

2. The degree of agitation which will resolve the aggregates into single grains, is (roughly) inversely as the size of the particles; or more properly, perhaps, inversely as their hydraulic value.

3. The tendency to flocculation varies inversely as the temperature. In water near the boiling point it is very slight; so strikingly less, that at one time I seriously contemplated the use of such water in the mechanical analysis of soils, in lieu of the mechanical stirring. The difficulties of construction and manipulation of course render this method undesirable, even if it were altogether efficient.

4. The presence of alcohol, ether, and of *caustic* or *carbonated alkalies*, materially diminishes the tendency to flocculation; while the presence of acids and neutral salts seems to increase it.

5. As between sediments of equal hydraulic value but different density, the tendency to flocculation seems to be greater with the less dense particles.

My object being, at the time, not so much the determination of a question of abstract physics, but the finding of an accurate and practicable method of mechanical soil-analysis, I have not pursued farther the interesting points suggested by 4 and 5. The observations made, however, rendered quite obvious a close relation between the capillary properties of liquids and the flocculative tendency of sediments suspended in them. Just what this relation is, must be determined by farther experiment; nor will I undertake to discuss at this time what is the precise nature of the attraction that causes the formation of these flocculated aggregates, and when formed holds them together. Regarding the single particles as irregular spheroids, each of which can, at best, come in contact at three points with any other particle, it cannot be mere surface adhesion independent of the liquid; and the particles being submerged, there is no meniscus to create an adhesive tension. Since experiment shows that the flocculative tendency is measurably governed by the cohesion-coëfficient of the liquid, it seems necessary to assume that capillary films of the latter interposed between the surfaces of solids, *do* create a considerable adhesive tension even in the absence of a meniscus; an assumption that would seem to be rendered necessary also by the enormous increase of adhesion caused by the interposition of a solid film of liquid between plane plates, even when submerged, as compared with that of, e. g., two watch glasses adhering only by their wetted edges, with two concentric circles of menisci. *A priori*, it is to be supposed that the surface tension known to exist between two liquid surfaces, must exist, and exert a corresponding influence between the surfaces of solids and liquids, apart from any meniscal action. I am unable to find that any exhaustive investigation of this particular phase of the subject of molecular attraction has as yet been made.

It is of course to be expected, that the adhesion of the particles constituting one of these floccules will be very materially increased whenever the formation of menisci between them becomes possible by the removal of the general liquid mass. Suppose one of the floccules to be "stranded," it will in the first place remain immersed in a sensibly spherical drop of liquid. As this liquid evaporates, the spherical surface will become pitted with menisci forming between the single projecting particles; and as these menisci diminish their radius by still farther evaporation, the force with which they hold the particles together will increase, until it reaches a maximum, the position of which (expressed in the liquid-percentage of the mass) must be sensibly a function of the size of the constituent particles. As the evaporation progresses beyond this point of maximum, the adhesion of the constituent particles must diminish by reason of the disappearance of the smaller menisci; and when finally the point is reached when liquid water ceases to exist between the surfaces, the slightest touch, or sometimes even the weight of the particles themselves, will cause a complete dissolution of the floccule, which then flattens down into a pile of single granules.

All this can readily be observed by any one in the progress of a mechanical soil analysis; provided only that the complete separation of the clay from the siliceous sediments has been previously accomplished in the manner set forth in my former paper. The presence of flocculated or coagulated clay modifies the phenomena, in so far as it tends to hold the floccules together under circumstances that in its absence would have caused a complete collapse.

I now proceed to discuss some of the obvious bearings of the phenomenon of flocculation upon natural as well as artificial processes.

First, as regards the formation of aqueous deposits, it is obvious that it is but very rarely that they can be deposited otherwise than in a flocculated condition. As a rule, the water cannot assort in accordance with their individual hydraulic value, any sediments below that of 8^{mm} per second, or about $0{\cdot}2^{mm}$ diameter; and the complex particles thus formed are deposited along with single ones of much higher hydraulic value. The deposition of such an intractable substance as "pure clay" would be, as well as that of any one sediment of very limited range as to size or hydraulic value, is thus practically impossible, save under very exceptional circumstances. Were this otherwise, the local occurrence of soils and rocks of extreme character, both as to chemical and mechanical composition, would be much more frequent than is actually the case.

The fact that, as a consequence of known processes in the formation of aqueous deposits, the latter must be considered as constituted of compound spheroid granules, at once determines the view of Tyndall regarding the cause of slaty cleavage by compression, to be the true one, as against that of Sorby. Yet Tyndall, while assuming such structure to exist, fails to assign any definite cause, outside of crystalline masses. It would be interesting to make the counter-test, and prove that when (as can readily be done) the flocculated structure is destroyed previous to the application of pressure, slaty structure does not result, either at all, or in as marked a degree. I hope to make this experiment before long.

The destruction of the floccules is effected by what is known in the arts as the tamping or "puddling" of earth or clay. It is the result of violent agitation with water, or of kneading, boiling, or finally, to a certain extent, of freezing. All these agencies are employed by the workers in clay for the purpose of increasing plasticity, which depends essentially upon the finest possible condition of the material to be worked: for when it is in a flocculent or granular condition, it assumes more or less the properties of sand.

The latter fact can be most strikingly shown in the following manner: Let any clay or clay soil be worked into a plastic paste with water and then dried; the result will be a mass of almost stony hardness. Add to the same paste about 0·5 per cent of caustic lime, which substance (as shown by Schlœsing and myself) possesses in an eminent degree the property of coagulating clay into floccules. The diminution of plasticity will be obvious at once, even in the wet condition; and upon drying, the mass will fall into a pile of crumbs upon a mere touch, or dropping it on the floor—a striking lecture experiment, as well as a convincing illustration of the effect of liming upon clay soils, in rendering them "warmer" and more readily tilled. I found that bubbling carbonic acid gas through a magma of the limed clay for twenty-four hours, when all alkaline reaction had disappeared, had failed to restore the plasticity even when, after drying, the carbonate solution had been destroyed. This agrees with the experience of farmers that the "lightening" effect of a liming continues for years to be very manifest, and is never entirely lost. It is well known that marling produces similar but weaker effects; and the same can be observed wherever one and the same clay soil is partially subject to washings from limestone hills, or to the admixture of underlying calcareous strata. Schlœsing's experiments on the efficacy of lime water in coagulating clay water, show its effect to exceed greatly that of any other calcium compounds; and so far as my experiments go, I find those of no other element approaching, in this respect, those of calcium. In this connection Dr. John LeConte's remarks on the exceptional transparency of calcareous waters in Florida (Proc. Am. Assoc. Adv. Sci., 1860, p. 33) should be called to mind.

Were any farther proof needed regarding the nature of the effects of tillage upon soils, this lime experiment would supply it. *It is the loosely flocculated aggregation of the soil particles which constitutes good tilth*, as against the partially "tamped" condition which results from the mechanical action of rains and (in silt soils) of drying. Tillage acts not merely, as Professor Johnson says (On some Reasons for Tillage, Rep. Sec'y, Conn. Board of Agr., 1877–8): "by lifting up masses of soil, turning them and letting them fall so that the close contact produced by rest (?) and moving water is broken, and the grains of sand and the minute aggregations of loam are brought into new positions with regard to each other, and to greater distances from each other." These "new positions" and "greater distances" are brought about and maintained by the phenomenon of flocculation, by the formation of compound crumbs ("ackerkrume"), which can be readily seen and compared with the partially "tamped" soil on the land side, in any furrow made in well-tilled cultivated soil; and they relate to each other, both as to bulk and permeability, in mass, somewhat as powdered lead would to bird-shot. If this be the correct view, mere *rest* cannot, in general, produce any compacting influence on soils, such as is claimed (loc. cit.) by Professor Johnson; and I think the proof that it is innocent of any such action is found in the case of any virgin soil in forests, where the protecting covering of leaves assures the most absolute rest to the soil for centuries, and where, nevertheless, it is always in such tilth as our best-tilled fields might envy.

There is one class of soils, nevertheless, in which "rest" may be said to produce compacting, to wit: those consisting of siliceous silt with not clay enough to maintain them in position after drying; so that the loose arches of the floccules collapse by their own weight, or by the least shocks. This happens not unfrequently in river-sediment soils; and the curious result is that they are injured by plowing when very *dry*, in the same way that clayey soils are when plowed too *wet*. In both cases the effect is to destroy the floccules and produce a single-grain or tamped structure, which it requires several seasons' tillage to rectify. In the case of "beating" rains, the hardening effect upon the surface is of course due to the mechanical destruction of the floccules, followed by the infiltration with "clay water," which, in drying, acts as a hardening cement.

In some soils the point of maximum cohesion of the floccules, and consequently the tendency to maximum flocculation, lies between very narrow limits; as the farmer says, they have to be plowed when "just right," or not at all, on pains of injuring their tilth for years. I find among these not only the clay soils proper, but another class consisting of uniformly fine silts (chiefly 1^{mm} hydraulic value, and below) with but very little clay; which, when wet, are said to "work like putty," and when a very little too dry remain cloddy. Those in which the tillage may be done within a wide range of condition as to moisture, are those containing a great variety of sediments of *all* sizes; colluvial rather than alluvial, and usually called "loams." The exact conditions of maximum flocculability, however, and the influence exerted thereon by each of the several sediments and their combinations, still remain to be determined; and the task is not a light one.

It is known that the longer a soil has been maintained in perfect tilth, the more difficult it is to "puddle" it by wet plowing. This is doubtless owing to the gradual cementation of the floccules by the soil water; which fixes them, as it were, more or less permanently.

As to the action of frost on soils, it is clear that as the water-menisci within the floccules freeze, the soil must be reduced to its ultimate mechanical elements, held apart by the ice crystals. It is thus readily intelligible why plowing too wet, *after a freeze*, is so much more injurious to tilth than when done after only a rain. But when the thawed soil is allowed first to assume its proper moisture-condition, the newly-formed floccules are of course looser than ever; and in clay and loam soils the most perfect tilth is the result, while *clayless* ones are measurably "*puddled*" *by frost.*

The "ripening" of potter's clay by freezing, boiling, alternate wetting and drying, or finally by thorough working, is obviously based on the same process of "atomization." Not only do these processes destroy the mechanically formed aggregates, but boiling at least, and probably all the rest, serve to reduce the kaolinite ingredient of soils and clays to the amorphous, plastic, diffusible modification. As to boiling, I have succeeded in rendering diffusible and very plastic, the seventy-five per cent of clayey ingredient in a white, chalky pipe clay, resembling kaolin, and which naturally is but very slightly plastic, by boiling for about eighty-five hours. In this case the clay water showed, even after a week's subsidence, a distinctly dotted structure under a power of five hundred diameters, instead of the non-resolvable cloud exhibited by the water from naturally plastic clays. Since lithological evidence proves conclusively that mere soaking in water does not produce the transformation, unless accompanied by mechanical agencies: we can hardly escape the conclusion that the difference between the plastic and non-plastic kaolinite is merely mechanical, and not properly comparable to that between quartz and chalcedony.

In regard to the action of alkaline carbonates in preventing flocculation, and thus rendering tillage difficult or impossible, many of the "alkali soils" of California supply striking examples. The name is popularly applied, almost indiscriminately, to any soil containing such excess of soluble salts of any kind, as to become apparent by efflorescence. Among these, however, the soils impregnated with alkaline carbonates may generally be recognized by their extreme compactness, and refractoriness under tillage; and by the fact that they usually form "low spots" in the general surface of non-alkaline land, where turbid clay water, dark with dissolved humus, will lie for weeks after the higher land appears dry. I give below the results of the comparative mechanical analysis of two samples of soil, taken within twelve feet of each other, on an alkaline tract in the neighborhood of Stockton, Cal. One of these represents a fertile "ridge" soil, in excellent tilth, lying (naturally) about eighteen inches higher than the soil of the adjacent alkali tract, in which the same soils alternate on hillocks and in depressions, so as to render it impossible to cultivate one without the other. The alkali soil had been plowed, cross-plowed, rolled and harrowed, until the harrow produced no further effect; and the result was a seed-bed of soil clods ranging from the size of a pea to that of a billiard ball, but no tilth. At the same time, portions of the "ridge" soil so treated were reduced to an ashy condition of tilth. Inspection seemed to show that the two soils differ but little in mechanical composition; not nearly enough to account for such difference of tilling qualities. The analyses resulted thus:

STOCKTON SOILS.

	Non-alkaline.	Alkaline.
Clay,	20·8	24·6
Sediment $<0\cdot25^{mm}$ hydraulic value	32·0	26·1
" 0·25 " "	3·3	3·3
" 0·50 " "	6·6	9·4
" 1·0 " "	5·6	6·2
" 2·0 " "	7·3	6·2
" 4·0 " "	7·5	5·4
" 8·0 " "	5·7	4·8
" 16·0 " "	4·8	4·7
" 32·0 " "	1·5	5·9
" 64·0 " "	1·2	1·1
	96·4	97·7

The only material difference in the mechanical composition of these two soils is in the relative amounts of clay and finest sediment; and this is perhaps more apparent than real, inasmuch as the disintegrating action of the alkali has doubtless been instrumental in bringing out as "clay" in the alkaline soil, a portion of what in the other has remained behind in the finest sediment. Still, as the alkali soil lies close to, and lower than, the tillable soil, and receives its washings, it should contain somewhat more clay than the latter. Taking the results as they are, however, it is clear that the mechanical composition of the alkali soil gives no clue to the cause of its behavior under tillage, since a soil containing no more than 24·6 per cent of clay, with all sediments above the finest so evenly distributed, should be classed simply as a "clayey loam."

The dark brown soil-extract, leached from the alkali soil, amounted, after ignition and treatment with carbonic acid, to 0·251 per cent. Of this amount, 0·158 was again soluble, 0·093 remaining behind as earthy salts, etc. The soluble part was constituted thus:

Carbonate of sodium	52·74
Chlorid of sodium	38·08
Sulphate of sodium	13·26
Tri-sodic phosphate	1·83
	100·91

The insoluble part of the aqueous extract gave:

Carbonate of calcium	14·02
Tri-calcic phosphate	5·37
Tri-magnesic phosphate	5·77
Silica (soluble in Na_2CO_3)	24·37
Iron oxides, alumina, and some clay (by difference)	50·47
	100.00

It will be observed that notwithstanding the presence of considerable amounts of neutral sodium and calcium salts, that of about 0·08 per cent of carbonate of sodium was sufficient to render the soil practically untillable. In this case, as well as in that of a very large amount of similar "alkali land" in the state, the application of a sufficient amount of gypsum to decompose the alkaline carbonate, produces a surprising change; which, on the small scale, can be perceived at once, but in the field, naturally requires a season's tillage to become effective as to tilth. It at once prevents, of course, the injury to seeds and growing plants arising from the corrosive action of the alkaline carbonate, which helps to render them unprofitable for culture.

My suggestion of the use of gypsum on soils of this character, not containing enough of soluble salts to render their presence objectionable when neutral, has already been tested in practice with the most satisfactory results. It will be seen that among the soluble salts is a comparatively very large amount of alkaline and earthy phosphates, which (in accordance with Grandeau's researches) follow the humus acids into solution even when the solvent is alkaline. Were the soil to be thorough-drained (as has sometimes been done in order to relieve the excess of salts) these phosphates would be carried off in the drain water. The use of gypsum prevents this loss by rendering the phosphates insoluble together with the humus, albeit in such a finely divided state as to remain perfectly available to vegetation. The double benefit thus gained manifests itself in the exuberant fertility of the soils so treated. I shall hereafter describe more in detail the very singular features of the California alkali soils, but mention the present as a conspicuous example of the benefits to be derived from an intelligent, direct investigation of soils.

Among the many other cases in which the phenomenon of flocculation comes into play in technical practice, I only mention that of ore extraction by means of solvents. Were the solvent liquid poured on the finely pulverized dry ore, it would permeate it with extreme slowness, and the subsequent washing-out of the solution would be tedious in the extreme. It is therefore the universal practice with all fine ores to dampen them first with an amount of water varying according to the nature and fineness of the ore, and then by stirring or working over, to flocculate them, or, in technical language, to render them "woolly." Care is then taken to prevent the inflow of water from "puddling" the charge by direct impact, and all stirring or concussion whereby the flocculated arrangement of the particles might be broken down, is carefully avoided.

Similarly, of course, the leaching-out the soluble salts from a true "alkali soil" by the ordinary process of percolation, is almost impossible in consequence of the entire absence of flocculation; and can only be accomplished by a long series of decantations followed by evaporation to dryness, extraction of the residue by quiet upward diffusion, and syphoning-off. Even thus, a final correction for clay that has defied both filtration and subsidence, must almost always be made.

ART. XXV.—*Remarks on the Jura-Trias of Western North America;* by C. A. WHITE, Paleontologist to the U. S. Geological Survey.

THE fact is generally known that among North American rocks neither the Jurassic nor Triassic period are any where so well represented as they are in certain parts of Europe. Indeed, until within a few years past it has not been claimed as demonstrated by the presence of characteristic types of fossils that any strata of the western territories of the United States are exactly equivalent with any Triassic strata of Europe, although a certain series, distributed over a large portion of that great western region has been recognized as Jurassic; and also a certain sandstone formation, usually of a red or reddish color, generally present beneath that Jurassic series, has been very generally referred to the Trias. It is my present purpose to offer some remarks upon these western Mesozoic formations, but not now to consider those strata which are commonly referred to the Triassic period in Connecticut and certain Atlantic States farther south.

Some modification of the views concerning these western formations that have been just indicated was produced, but the elucidation of the question of actual synchronism of these two groups with European strata hardly advanced by the following circumstances. The sandstone formation before referred to, which, from its prevalent color has been often designated as the "Red Beds," had been generally regarded as unfossiliferous, except that some imperfect vertebrate remains and an abundance of siliçified wood have been found in its strata; but Dr. Hayden, in 1869, published* the statement that he had found unmistakable Jurassic fossils near the base of this group which until then had been referred to the Trias almost without question. Also, in 1874, Mr. E. E. Howell, then in charge of one of Professor Powell's parties, collected in southern Utah, from the lower portion of the formation in question, several species of invertebrate fossils, some of which, at least, I regard as specifically identical with well-known species which, until then, had been found only in the unquestioned Jurassic strata of the western territories.† As far as this paleontological evidence extended, it seemed to indicate that all the Mesozoic strata of that great region east of western Nevada, and beneath the Dakota group of the Cretaceous series belong to one and the same epoch. The impression however still prevailing that the Triassic period, at least in part, is really represented by the Red Beds, the term Jura-Trias began to be used to designate collectively that formation together with the Jurassic strata above it. This collective designation seems to have met with general approval and, although our knowledge concerning these strata and their equivalents is increasing, it seems advisable to continue it until further investigation shall enable us to fix upon some definite horizon for their separation.

None of the foregoing remarks are intended to apply to the great development of Upper Triassic strata which, as is well known, exist near the western border of the continent. The existence of these strata was first made known in 1864, by the publication of volume I, Paleontology of California; and they were still further described in the lately published volumes of the United States Geological Exploration, 40th Parallel. In both of these works the contained fossils are fully illustrated and described, and the strata are, by those fossils, referred to the horizon of the St. Cassian, Aussee, and Hallstadt deposits of Europe. Professor Whitney says in the first work just cited: "This great Triassic belt of the Pacific coast has been most fully explored by the survey in the latitude of 40°, and over a width east and west of nearly four degrees of longitude (117° to 121°) . . . . But sufficient paleontological evidence has been obtained to enable us to state that this formation extends from Mexico to British Columbia, and that it occupies a vast area, although much broken up, interrupted by eruptive rocks, and covered in many places by heavy accumulations of volcanic materials."

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* See page 11, Geol. Rep. Expl. Yellowstone and Missouri Rivers. By F. V. Hayden, under the direction of Capt. W. F. Raynolds, Corps of Engineers U. S. A. Made in 1860 and published in 1869. 8vo, pamphlet.

† See White's paleontological chapter in Powell's Report on the Geology of the Uinta Mountains, pages 80 and 87.

No fossils, however, as already stated, or at least no invertebrates, were known to exist in any North American strata east of that region which could be confidently referred to the Triassic period, until the autumn of 1877, when a collection was brought in by one of the parties of the United States Geological Survey of the Territories, in charge of Dr. F. V. Hayden, which was found to contain molluscan types that are plainly Triassic. The collection referred to was made by Dr. A. C. Peale, field geologist, from two or three localities in southeastern Idaho, and which, with the other collections of the survey, came into my hands for study. They have, however, only lately received investigation, and their preliminary publication will soon be made in Part I, vol. v, Bull. U. S. Geol. Sur. Terr.

The fossils which have been obtained at numerous localities in different parts of the western territories and referred with little or no question to the Jurassic period are well known; such, for example, as *Pentacrinus asteriscus* Meek and Hayden, *Belemnites densus* M. & H., *Camptonectes bellistriatus* M. & H., *Eumicrotis curta* Hall, *Ostrea strigilecula* White, &c. Wherever in that region a collection of Jurassic (or as they have come to be commonly designated, Jura-Trias) fossils has been made, some one or more of these species has generally been found among them; and the new forms, whenever they have been discovered, have not generally been in excess of those which were previously known, thus suggesting the discovery of no separate horizons. Almost the contrary, however, is the case with the collection from the localities here referred to in southeastern Idaho, because, out of the list of the species obtained there and presently to be mentioned, only three were previously known, and only one (*Eumicrotis curta*) has ever been found associated with well-known Jurassic fossils.

At the principal one of these localities, which is about sixty-five miles north of the southern, and eighteen miles west of the eastern, boundary of Idaho, Dr. Peale found the Jura-Trias strata in question to be about 3,000 feet in thickness of alternating limestones, sandy shales and sandstones, with about 1,800 feet of Carboniferous strata beneath them, and with which they are apparently strictly conformable. He found in that immediate vicinity no exposures of the Red Beds, which have so generally been referred to the Trias, but he recognized them at some localities only a few miles away; and he is confident that they occupy a position immediately above the uppermost strata of the series exposed at the locality here especially referred to. It thus appears that this fossiliferous series, containing true Triassic types, occupies a position beneath the comparatively unfossiliferous Red Beds which were so long supposed to be the only representatives of the Trias in that great region; and that they separate the former from the well-known Jurassic series. The fossils of this lower series were found at different horizons within the thickness of 3,000 feet exposed at the locality mentioned, the following being a list of them:

1. *Terebratula semisimplex* White; 2. *T. augusta* Hall & Whitfield?; 3. *Aviculopecten Idahoensis* Meek; 4. *A. Pealei* W.; 5. *A. altus* W.; 6. *Eumicrotis curta* Hall; 7. *Meekoceras aplanatum* W.; 8. *M. Mushbachanus* W.; 9. *M. gracilitatus* W.; 10. *Arcestes? cirratus* W.; 11. *A.?*——?

All except Nos. 2, 3 and 6 of this list are new forms, and they have hitherto been found only within that limited area in southeastern Idaho. No. 2, which is referred by its authors to the Jurassic of Nevada, is doubtfully identified as above. The type specimens of No. 3 were obtained from another locality in southeastern Idaho several years ago, and doubtless from the same horizon as that of the foregoing list. No. 6 is a common fossil and has by different geologists been reported from numerous and widely separated Jurassic localities in the west. Indeed it is at present, by this species alone, that the collection of the foregoing list is connected with the well-recognized Jurassic of that great region.

The Brachiopods and Conchifers of this collection would not have attracted particular attention under the circumstances, but the Cephalopods present types which had never been found in American Jurassic strata, but are clearly Triassic; one of which was a new generic form. Having recognized the unique character of this collection, the Triassic type of the Cephalopods, and the fact that although closely related to typical *Ceratites*, one group especially presented some important generic modifications, concerning which I desired the opinion of Professor Alpheus Hyatt, whose excellent and exhaustive labors upon this class of fossils are so well known. I therefore sent them to him for examination, and of the two, or perhaps three, generic forms which they embrace he describes one as new, under the name of *Meekoceras*, and refers the others, doubtfully, because of the imperfection of the specimens, to *Arcestes* Suess.

Now comes an interesting and, in view of the recognized St. Cassian age of the Nevada Trias before referred to, a somewhat unexpected fact. The types of these Cephalopods, as distinctly stated by Professor Hyatt, have close affinities with those of the Muschelkalk or Middle Trias of Europe, and not with those of the St. Cassian, Aussee, and Hallstadt deposits of the European Upper Trias. This fact, however, need not excite especial surprise when it is remembered that the southeastern Idaho locality is about four hundred miles eastward from that of the Nevada Trias; and, furthermore, that the positions which they occupy are respectively adjacent to east and west borders of an extensive area which was above the level of the sea during the whole of Mesozoic time; and which extended from the southern to the northern portion of North America. The deposits of the two regions were therefore never directly continuous, and probably no physical connection of their strata respectively, need be sought for.

With this discovery of a true Triassic fauna east of that long continental area of Mesozoic time, new interest is given to the study of the earlier Mesozoic rocks of the western territories. There are such indications of an intimate faunal relationship between these Triassic strata of southeastern Idaho and the true Jurassic strata of that great western region, that I still prefer to hold to the provisional designation of Jura-Trias for the whole of them. But in view of the great development of the first mentioned strata, although now known only in a limited area, and of the distinctively Triassic facies of its types, especially the Cephalopods, it seems not improbable that we may yet find a physical plane for their separation as Jurassic and Triassic groups respectively.

ART. XXVI.—*On the Illumination of Lines of Molecular Pressure, and the Trajectory of Molecules;* by WILLIAM CROOKES, F.R.S., V.P.C.S.*

Induction Spark through Rarefied Gases.—Dark Space round the Negative Pole.—The author has examined the dark space which appears round the negative pole of an ordinary vacuum-tube when the spark from an induction-coil is passed through it. He describes many experiments with different kinds of poles, a varying intensity of spark, and different gases, and arrives at the following propositions:—

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* Abstract of a paper read before the Royal Society, Dec. 5, 1878. (Phil. Mag., Jan., 1879.)

Illumination of Lines of Molecular Pressure.—a. Setting up an intense molecular vibration in a disk of metal by electrical means excites a molecular disturbance which affects the surface of the disk and the surrounding gas. With a dense gas the disturbance extends a short distance only from the metal; but as rarefaction continues, the layer of molecular disturbance increases in thickness. In air at a pressure of 0·078 millim. this molecular disturbance extends for at least 8 millims. from the surface of the disk, forming an oblate spheroid around it.

b. The diameter of this dark space varies with the exhaustion, with the kind of gas in which it is produced, with the temperature of the negative pole, and, in a slight degree, with the intensity of the spark. For equal degrees of exhaustion it is greatest in hydrogen and least in carbonic acid, as compared with air.

c. The shape and size of this dark space do not vary with the distance separating the poles, nor (or only very slightly) with alteration of battery-power, nor with intensity of spark. When the power is great the brilliancy of the unoccupied parts of the tube overpowers the dark space, rendering it difficult of observation; but, on careful scrutiny, it may still be seen unchanged in size; nor does it alter even when, with a very faint spark, it is scarcely visible. On still further reduction of the power it fades entirely away, but without change of form.

The author describes numerous experiments, devised to ascertain if this visible layer of molecular disturbance is identical with the invisible layer of molecular pressure or stress, the investigation of which has occupied him for some years.

The Electrical Radiometer.—One of these experiments is as follows:—An ordinary radiometer is made, with aluminium disks for vanes, each disk coated with a film of mica. The fly is supported by a hard steel cup instead of a glass cup; and the needle-point on which it works is connected by means of a wire with a platinum terminal sealed into the glass; at the top of the radiometer-bulb a second terminal is sealed in. The radiometer can therefore be connected with an induction-coil, the movable fly being made the negative pole.

Passing over the phenomena observed at low exhaustions, the author finds that, when connected with the coil, a halo of a velvety violet light forms on the metallic side of the vanes, the mica side remaining dark throughout these experiments. As the pressure diminishes a dark space is seen to separate the violet halo from the metal. At a pressure of half a millim. this dark space extends to the glass, and positive rotation commences.

On continuing the exhaustion, the dark space further widens out and appears to flatten itself against the glass, and the rotation becomes very rapid.

When aluminium cups are used for the vanes instead of disks backed with mica, similar appearances are seen. The velvety violet halo forms over each side of the cup. On increasing the exhaustion the dark space widens out, retaining almost exactly the shape of the cup. The bright margin of the dark space becomes concentrated at the concave side of the cup to a luminous focus, and widens out at the convex side. On further exhaustion, the dark space on the convex side touches the glass, when positive rotation commences, becoming very rapid as the dark space further increases in size and ultimately flattens against the glass.

Convergence of Molecular Rays to a Focus.—The subject next investigated is the convergence of the lines of force to a focus, as observed with the aluminium cup. As this could not be accomplished during rapid rotation, an instrument was made having the cup-shaped negative pole fixed instead of movable. On exhaustion, the convergence of the lines of force to a focus at the concave side was well observed. When the dark space is very much larger than the cup, it forms an irregular ellipsoid, drawn in toward the focal point. Inside the luminous boundary a focus of dark violet light can be seen converging, and, as the rays diverge on the other side of the focus, spreading beyond the margin of the dark space—the whole appearance being strikingly similar to the rays of the sun reflected from a concave mirror through a foggy atmosphere.

Green Phosphorescent Light of Molecular Impact.—At very high exhaustions the dark space becomes so large that it fills the tube. Careful scrutiny still shows the presence of the dark violet focus; and the part of the glass on which fall the rays diverging from this focus shows a sharply defined spot of greenish-yellow light. On still further exhaustion, and especially if the cup is made positive, the whole bulb becomes beautifully illuminated with greenish-yellow phosphorescent light.

This greenish-yellow phosphorescence, characteristic of high exhaustions, is frequently spoken of in the paper. It must be remembered, however, that the particular color is due to the special kind of soft German glass used. Other kinds of glass produce a different color. The phosphorescence takes place only under the influence of the negative pole. At an exhaustion of 4 M* no light other than this is seen in the apparatus. At 0·9 M the phosphorescence is about at its maximum. When the exhaustion reaches 0·15 M, the spark has a difficulty in passing, and the green light appears occasionally in flashes only. At 0·06 M the vacuum is almost non-conductive; and a spark can be forced through only by increasing the intensity of the coil and well insulating the tube and wires leading to it. Beyond that exhaustion nothing has been observed.

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* M signifies the millionths of an atmosphere.

Focus of Molecular Force.—In an apparatus specially constructed for observing the position of the focus the author found that the focal point of the green phosphorescent light was at the center of curvature, showing that the molecules by which it is produced are projected in a direction normal to the surface of the pole. Before reaching the heat exhaustion for the green light, another focus of blue-violet light is observed; this varies in position, getting further from the pole as the exhaustion increases. In the apparatus described, at an exhaustion of 19·3 M, these two foci are seen simultaneously, the green being at the center of the curvature, while the blue focus is at nearly twice the distance.

Nature of the Green Phosphorescent Light.—The author adduces the following characteristics of the green phosphorescent light, as distinguishing it from the ordinary light observed in vacuum-tubes at low exhaustions:

a. The green focus cannot be seen in the space of the tube, but where the projected beam strikes the glass only.

b. The position of the positive pole in the tube makes scarcely any difference in the direction and intensity of the lines of force which produce the green light. The positive pole may be placed in the tube either at the extremity opposite the negative pole, or below it, or by its side.

c. The spectrum of the green light is a continuous one, most of the red and the higher blue rays being absent; while the spectrum of the light observed in the tube at lower exhaustions is characteristic of the residual gas. No difference can be detected by spectrum-examination in the green light, whether the residual gas be nitrogen, hydrogen, or carbonic acid.

d. The green phosphorescence commences at a different exhaustion in different gases.

e. The viscosity of a gas is almost as persistent a characteristic of its individuality as its spectrum. The author refers to a preliminary note and a diagram* of the variation of viscosity of air, hydrogen, and other gases at exhaustions between 240 M and 0·1 M. From these and other unpublished results, the author finds that the viscosity of a gas undergoes very little diminution between atmospheric pressure and an exhaustion at which the green phosphorescence could be detected. When, however, the spectral and other characteristics of the gas begin to disappear, the viscosity also commences to decline; and at an exhaustion at which the green phosphorescence is most brilliant the viscosity has rapidly sunk to an insignificant amount.

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* Proc. Roy. Soc., Nov. 16, 1876, vol. xxv, p. 305.

f. The rays exciting green phosphorescence will not turn a corner in the slightest degree, but radiate from the negative pole in straight lines, casting strong and sharply defined shadows from objects which happen to be in their path. On the other hand, the ordinary luminescence of vacuum-tubes will travel hither and thither along any number of curves and angles.

Projection of Molecular Shadows.—The author next examines the phenomena of shadows cast by the green light. The best and sharpest shadows are cast by flat disks and not by narrow-pointed poles; no green light whatever is seen in the shadow itself, no matter how thin, or whatever may be the substance from which it is thrown.

From these and other experiments, fully described in the paper, he ventures to advance the theory that the induction-spark actually illuminates the lines of molecular pressure caused by the electrical excitement of the negative pole. The thickness of the dark space is the measure of the mean length of the path between successive collisions of the molecules. The extra velocity with which the molecules rebound from the excited negative pole keep back the more slowly moving molecules which are advancing towards that pole. The conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the collisions.

When the exhaustion is sufficiently high for the mean length of path between successive collisions to be greater than the distance between the fly and the glass, the swiftly moving rebounding molecules spend their force, in part or in whole, on the sides of the vessel, and the production of light is the consequence of this sudden arrest of velocity. The light actually proceeds from the glass, and is caused by fluorescence or phosphorescence on its surface. No light is produced by a mica or quartz screen; and the more fluorescent the material the better the luminosity. Here the consideration arises that the greenish-yellow light is an effect of the direct impact of the molecules in the same electrical state on the surface of the glass. The shadows are not optical, but are molecular shadows revealed only by an ordinary illuminating effect; this is proved by the sharpness of the shadows when projected from a wide pole.

Phosphorescence of Thin Films.—An experiment is next described in which a film of uranium glass, sufficiently thin to show colors of thin plates, is placed in front of a thick plate of the same glass, the whole being closed in a tube with terminals and exhausted to a few millionths of an atmosphere. Of this the following observations are recorded:—

a. The uranium film, being next to the negative pole, casts a strong shadow on the plate.

b. On making contact with the coil, the thin film flashes out suddenly all over its surface with a yellowish phosphorescence, which, however, instantly disappears. The uncovered part of the plate does not become phosphorescent quite suddenly, but the phosphorescence is permanent as long as the coil is kept at work.

c. With an exceedingly faint spark the film remains more luminous than the plate; but on intensifying the spark, the luminosity of the film sinks, and that of the uncovered part of the plate increases.

d. If a single intense spark be suddenly sent though the tube, the film becomes very luminous, while the plate remains dark.

These experiments are conclusive against the phosphorescence being an effect of the radiation of the phosphorogenic ultra-violet light from a thin layer of arrested molecules at the surface of the glass; for were this the case, the film could under no circumstances be superior to the plate.

The momentary phosphorescence and rapid fading of the film prove more than this. The molecular bombardment is too much for the thin film. It responds thereto at first, but immediately gets heated by the impacts, and then ceases to be luminous. The plate, however, being thick, bears the hammering without growing hot enough to lose its power of phosphorescing.

Mechanical Action of Projected Molecules.—When the coil was first turned on, the thin film was driven back at the moment of becoming phosphorescent, showing that an actual material blow had been given by the molecules. Experiments are next described in which this mechanical action is rendered more evident. A small rotating fly, capable of being moved about in any part of an exhausted bulb, is used as an indicator; and by appropriate means the molecular shadow of an aluminium plate is projected along the bulb. Whether entirely in or entirely out of the shadow, the indicator scarcely moves; but when immersed so that one-half is exposed to molecular impact the fly rotates with extreme velocity.

Magnetic Deflection of Lines of Molecular Force.—With this apparatus another phenomenon was investigated. It is found that the stream of molecules whose impact on the glass occasions evolution of light is very sensitive to magnetic influence; and by bringing one pole of an electromagnet, or even of a small permanent magnet, near, the shadow can be twisted to the right or to the left.

When the little indicator was placed entirely within the molecular shadow no movement was produced. As soon, however, as an adjacent electromagnet was excited, the shadow was twisted half off the indicator, which immediately rotated with great speed.

The Trajectory of Molecules.—The amount of deflection of the stream of molecules forming a shadow is in proportion to the magnetic power employed.

The trajectory of the molecules forming the shadow is curved when under the magnetic influence; the action of the magnet is to twist the trajectory of the molecules round in a direction at an angle to the free path, and to a greater extent as they are nearer the magnet, the direction of twist being that of the electric current passing around the electromagnet.

Laws of Magnetic Deflection.—An apparatus was constructed so that the deflection of a spot of light was used instead of that of a shadow, a horseshoe magnet being placed underneath the negative pole to deflect the trajectory. The action of the north pole being to give the line of molecules a spiral twist one way, and that of the south pole being to twist in the other way the two poles side by side compel the line to move in a straight line up or down, along a plane at right angles to the plane of the magnet and a line joining its poles.

The ray of molecules does not appear to obey Ampère's law, as it would were it a perfectly flexible conductor, joining the negative and the positive pole. The molecules are projected from the negative; but the position of the positive pole—whether in front, at the side, or even behind the negative pole—has no influence on their subsequent behavior, either in producing phosphorescence, or mechanical effects, or in their magnetic deflection. The magnet gives their line of path a spiral twist, greater or less according to its power, but diminishing as the molecules get further off.

Numerous experiments were tried in this apparatus with different gases, and with the magnet in and out of position.

Working with exhausted air it was found that the spot of green phosphorescence on the screen is visible at an exhaustion of 102·6 millim., when the mean free path of the molecules, measured by the thickness of the dark space round the negative pole, is only 12 millims. Hence it follows that a number of molecules sufficient to excite green phosphorescence on the screen are projected the whole distance from the pole to the screen, or 102 millims., without being stopped by collisions.

Alteration of Molecular Velocity.—If we suppose the magnet to be permanently in position, and thus to exert a uniform downward pull on the molecules, we perceive that the trajectory is much curved at low exhaustions, and gets flatter as the exhaustion increases. A flatter trajectory corresponds to a higher velocity. This may arise from one of two conditions: either the initial impulse given by the negative pole is stronger or the resisting medium is rarer. The latter is probably the true one. The molecules which produce the green phosphorescence must be looked upon as in a state differing from those arrested by frequent collisions. The latter impede the velocity of the free molecules and allow longer time for magnetism to act on them; for, although the deflecting force of magnetism might be expected to increase with the velocity of the molecules, Prof. Stokes has pointed out that it would have to increase as the square of the velocity, in order that the deflection should be as great at high as at low velocities.

Comparing the free molecules to cannon-balls, the magnetic pull to the earth's gravitation, and the electrical excitation of the negative pole to the explosion of the powder in the gun, the trajectory will be flat when no gravitation acts, and curved when under the influence of gravitation. It is also much curved when the ball passes through a dense resisting medium; it is less curved when the resisting medium gets rarer; and, as already shown, intensifying the induction spark, equivalent to increasing the charge of powder, gives greater initial velocity, and therefore flattens the trajectory. The parallelism is still closer if we compare the evolution of light seen when the shot strikes the target, with the phosphorescence on the glass screen from molecular impacts.

Focus of Heat of Molecular Impact.—The author finally describes an apparatus in which he shows that great heat is evolved when the concentrated focus of rays from a nearly hemispherical aluminium cup is deflected sideways, to the walls of the glass tube, by a magnet. By using a somewhat larger hemisphere, and allowing the negative focus to fall on a strip of platinum-foil, the heat rises to the melting-point of platinum.

An Ultra-gaseous state of Matter.—The paper concludes with some theoretical speculations on the state in which the matter exists in these highly-exhausted vessels. The modern idea of the gaseous state is based upon the supposition that a given space contains millions and millions of molecules in rapid movement in all directions, each having millions of encounters in a second. In such a case, the length of the mean free path of the molecules is exceedingly small as compared with the dimensions of the vessel, and the properties which constitute the ordinary gaseous state of matter, which depend upon constant collisions, are observed. But by great rarefaction the free path is made so long that the hits in a given time may be disregarded in comparison with the misses, in which case the average molecule is allowed to obey its own motions or laws without interference; and if the mean free path is comparable to the dimensions of the vessel, the properties which constitute gaseity are reduced to a minimum, and the matter becomes exalted to an ultra-gaseous state, in which the very decided but hitherto masked properties now under investigation come into play.

Rays of Molecular Light.—In speaking of a ray of molecular light the author has been guided more by a desire for conciseness of expression than by a wish to advance a novel theory. But he believes that the comparison, under these special circumstances, is strictly correct, and that he is as well entitled to speak of a ray of molecular or emissive light when its presence is detected only by the light evolved when it falls on a suitable screen, as he is to speak of a sunbeam in a darkened room as a ray of vibratory or ordinary light when its presence is to be seen only by interposing an opaque body in its path. In each case the invisible line of force is spoken of as a ray of light; and if custom has sanctioned this as applied to the undulatory theory, it cannot be wrong to apply the expression to the emissive light. The term emissive light, must, however, be restricted to the rays between the negative pole and the luminous screen; the light by which the eye then sees the screen is, of course, undulatory.

The phenomena in these exhausted tubes reveal to physical science a new world—a world where matter exists in a fourth state, where the corpuscular theory of light holds good, and where light does not always move in a straight line—but where we can never enter, and in which we must be content to observe and experiment from the outside.

Art. XXVII.—*On the Chemical Composition of Triphylite;* by Samuel L. Penfield, Ph.B., Assistant in the Sheffield Laboratory.—*Contributions from the Sheffield Laboratory of Yale College*, No. LIII.

In June, 1877, I published* an analysis of triphylite from Grafton, New Hampshire, and showed that the composition of that variety of the species conformed to the general formula $\overset{\text{II}}{R}_3P_2O_8+\overset{\text{I}}{R}_3PO_4$. I am now able to add analyses of the same mineral from Norwich, Massachusetts, and from Bodenmais, Bavaria, and also of the allied manganese-lithium phosphate, lithiophilite, from Branchville, Conn.; the results of these analyses remove all doubt in regard to the true formula belonging to this group.

The specimen from Norwich, Massachusetts, I received from Professor Brush. He had previously identified it as† forming the nucleus of a large crystal of the well known pseudomorphous black phosphate of iron, manganese and lithium, which occurs at that locality associated with spodumene. This unaltered triphylite is very rare, but the specimen, a portion of which was used for analysis, was bright and lustrous, with the distinct cleavages, and all the physical characters of the original mineral. The following analyses give additional proof of its being quite free from alteration.

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* This Journal, III, xiii, 426, June, 1877.

† Ibid., II, xxxiv, 402, Nov. 1862.

(1.) Triphylite from Norwich, Mass.; color greyish green, specific gravity =3·534.

	I.	II.	Mean.		Atomic relation.	
P_2O_5	44·72	44·80	44·76	P		·630
FeO	26·40	26·40	26·40	Fe	·366	=·633
MnO	17·87	17·80	17·84	Mn	·251	
CaO	·16	·33	·24	Ca	·004	
MgO	·49	·45	·47	Mg	·012	
Li_2O	9·37	9·34	9·36	Li	·622	=·632
Na_2O	·32	·38	·35	Na	·010	
H_2O	·53	·30	·42			
	——	——	——	Li_2	·311	=·316
	99·86	99·80	99·84	Na_2	·005	

The analyses of the Bavarian triphylite which have been published do not agree very satisfactorily, and have left some doubt in regard to the true composition of the mineral. With a view to settling this point I have also analyzed an authentic specimen from Bodenmais, Bavaria. This was furnished to me by Professor Brush; he had received it from Dr. Hugo Müller, who had himself collected it at the locality. It was quite pure, and entirely free from any traces of alteration. The results of the analysis are given below; it will be seen that it has afforded an exceptionally large percentage of lithia.

(2.) Triphylite from Bodenmais; color light blue, specific gravity =3·549.

	I.	II.	Mean.		Atomic relation.	
P_2O_5	43·16	43·19	43·18	P		·608
FeO	36·23	36·20	36·21	Fe	·503	=·652
MnO	8·95	8·96	8·96	Mn	·126	
CaO	·08	·12	·10	Ca	·002	
MgO	·84	·83	·83	Mg	·021	
Li_2O	8·14	8·15	8·15	Li	·544	=·552
Na_2O	·31	·22	·26	Na	·008	
H_2O	·92	·82	·87			
Gangue	·82	·84	·83	Li_2	·272	=·276
	——	——	——	Na_2	·004	
	99·45	99·33	99·39			

These three localities, Bodenmais, Norwich and Grafton are, with that in Finland, the only ones at which the mineral triphylite has been found. In connection with these it is interesting to note the mineral lithiophilite from Branchville, Connecticut, recently described by Messrs. Brush and Dana* and shown by them to be analogous to triphylite in composition. This mineral was first analyzed by Mr. H. L. Wells of the Sheffield

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* This Journal, III, xvi, 119, August, 1878.

Laboratory. I have made an analysis of it, but of another and slightly different variety, obtained by Messrs. Brush and Dana since the publication of their paper and from an independent, though closely contiguous deposit. The material was particularly fresh and free from alteration.

The results of the analysis are as follows:

(3.) Lithiophilite from Branchville, Conn.; color light clove brown; specific gravity =3·482.

	I.	II.	Mean.		Atomic relation.	
P_2O_5	45·22	45·22	45·22	P	·636	
FeO	13·10	12·92	13·01	Fe	·180	=·631
MnO	31·93	32·12	32·02	Mn	·451	
Li_2O	9·26	----	9·26	Li	·618	=·628
Na_2O	·28	·30	·29	Na	·010	
H_2O	·17	----	·17			
Gangue	·31	·28	·29	Li_2	·309	=·314
			100·26	Na_2	·005	

In the following table the atomic ratio for

$$P : \overset{\text{II}}{R}(=Fe, Mn, Ca, Mg) : \overset{\text{I}}{R}(=Li, Na)$$

is given for each of the three above analyses, and also for the Grafton mineral as analyzed by me (l. c.) and for the lithiophilite analyzed by Mr. H. L. Wells (l. c.).

	P	:	$\overset{\text{II}}{R}$	:	$\overset{\text{I}}{R}$	=		:		:	
Triphylite, Bodenmais,	·608	:	·652	:	·552	=	1	:	1·07	:	0·91
" Norwich, Mass.,	·630	:	·633	:	·632	=	1	:	1·00	:	1·00
" Grafton, N. H.,	·620	:	·651	:	·598	=	1	:	1·05	:	0·97
Lithiophilite, Branchville, Penfield,	·636	:	·631	:	·628	=	1	:	0·99	:	0·98
" " Wells,	·628	:	·632	:	·580	=	1	:	1·00	:	0·93

All of these approach very closely to ratio 1 : 1 : 1, required by the general formula

$$\overset{\text{II}}{R}_3P_2O_8 + \overset{\text{I}}{R}_3PO_4 \quad \text{or} \quad \overset{\text{I}}{R}\overset{\text{II}}{R}PO_4.$$

The Bavarian mineral deviates most widely from this, and a similar though less pronounced deviation is seen in that found at Grafton. In all the five cases, however, it will be observed that the required ratio of 1 : 1·5 for $P : \overset{\text{II}}{R} + \overset{\text{I}}{R}_2$ is very nearly given, as is seen in the following table:

	P		$\overset{\text{II}}{R} + \overset{\text{I}}{R}_2$
Triphylite, Bodenmais,	1	:	1·52
" Norwich,	1	:	1·50
" Grafton,	1	:	1·53
Lithiophilite, Branchville, Penfield.	1	:	1·48
" " Wells,	1	:	1·47

In order to bring out the relations of the different varieties of triphylite to each other in respect to the amounts of iron and manganese contained in them, and also of these in turn to the allied species lithiophilite, the five analyses from which the above ratios were obtained are given together in the following table:

	Triphylite.			Lithiophilite.	
	(1.) Bodenmais.	(2.) Norwich.	(3.) Grafton.	(4.) Branchville (Penfield).	(5.) Branchville (Wells).
P_2O_5	43·18	44·76	44·03	45·22	44·67
FeO	36·21	26·40	26·23	13·01	4·02
MnO	8·96	17·84	18·21	32·02	40·86
CaO	·10	·24	·94	----	----
MgO	·83	·47	·59	----	----
Li_2O	8·15	9·36	8·79	9·26	8·63
K_2O	----	----	·32	----	----
Na_2O	·26	·35	·12	·29	·14
H_2O	·87	·42	1·47	·17	·82
Gangue	·83	----	----	·29	·64
	99·39	99·84	100·70	100·20	99·78

This series of analyses shows in a very striking way the transitions from triphylite, the phosphate of *iron* and lithium, to lithiophilite, the phosphate of *manganese* and lithium; to the first belongs the formula $LiFePO_4$ and to the second $LiMnPO_4$.

In closing this paper I wish to acknowledge my indebtedness to Professor George J. Brush, who has most liberally furnished me with the material needed for my examination.

Sheffield Laboratory, Dec. 16, 1878.

ART. XXVIII.—*Notes on the Mesozoic Strata of Virginia*; by WM. M. FONTAINE.

[Concluded from page 157.]

Petersburg Belt.—This exhibits many of the peculiar features seen in the Fredericksburg Belt, but on a more exaggerated scale. We do not however recognize more than one series. The strata are well exposed at Richmond in the lowest points reached by the erosion of the streams. They occur here with the Eocene and Miocene in place above them. They form the lowest visible beds in the river bank all the way down to Farrar's Island, and a short distance eastward of it. They also occur in a similar position in the banks of the Appomatox up to Petersburg, being in the vicinity of the rivers covered by only the lowest of the Eocene strata, the rest of the Tertiary having been removed. The canal cut by General Butler in the late war, through the narrow neck of Farrar's Island at Dutch Gap, in order to avoid the bend of the river, gives a good exposure. The description I shall give of the strata applies more particularly to the beds exposed at this last named locality, though it is applicable with some modifications throughout the belt. The beds incline gently eastward, and disappear under the Tertiary. It is not known how far they pass in this direction, but from their great comparative development where they disappear, they no doubt penetrate far under the Tertiary. The lithology and stratigraphy present many remarkable features, only a few of which can be noticed. The thickness of the strata and coarseness of the component matters, strange to say, is greatest at the farthest point to the east at which they show themselves, viz: near Dutch Gap, although the source of the material is to the west. Not more than fifty or sixty feet of strata appear in the banks of the stream here, but from the manner in which the bluffs descend beneath the water, and the depth of the latter, the total thickness near Dutch Gap cannot be less than one hundred and fifty feet, while near Richmond it is not more than fifty or sixty feet. The variableness of the material, and the complexity of the rapidly shifting planes of false-bedding are so great, that no two sections taken a few feet apart will be similar; indeed the entire mass has the character of a "Kame."

The greater portion and the finer matter of the beds is a sort of incoherent grit, composed of grains of quartz, particles of feldspar in all stages of decomposition, and scales of mica, all mingled together without sorting and devoid of lamination, forming a mass without bedding, but penetrated by numerous and intricate false-bedding planes. This material which is plainly derived from the granitic and gneissic rocks to the west, is filled with small stones which are scattered confusedly throughout its mass. These are usually composed of quartz. While this is the more common material, we often find that locally, most of the material is the previously mentioned white, non-plastic earth, mingled with great quantities of small Potsdam stones, the whole being formed of the debris of Potsdam strata. Throughout the series, beds and pockets of large stones occur of very variable extent and thickness. These are much more abundant towards the top. They seem to be formed by the local removal of the normal grit, and the filling of the excavations with the stones. Thus we find that a mass of large stones, composing nearly all of the visible bank of the stream, will pass abruptly into the ordinary pebbly grit, or even fine sandy matter. Such pockets of stones are composed almost entirely of Potsdam quartzite and sandstones, well rounded and smoothed. The stones are more commonly under eight to ten inches, but they occur a foot or more in diameter. They are usually packed in a finer material composed of Potsdam debris. While these masses of stones are especially abundant in the highest portions of the series, they are not confined to this. Thus the lowest stratum that I saw exposed, was composed in one locality of rounded Potsdam stones, six, eight, ten and even twelve inches in diameter, packed as closely as possible together, and looking much like a section of the cobble-paved streets of Richmond.

Toward the top of the series, we find very commonly short layers, and nests of clay enveloped in the grit, but so sharply distinct from it that the clay seems to have been laid down on depressions in the surface of the grit during pauses in the deposition of this material. The distinctness is so great that at the line of junction of the two, the grains of the grit may be picked out separately from the clay. This clay sometimes, however, is interstratified for some distance with the sandy matter, the layers of sandy grit and clay alternating but not passing into each other. The clay is most commonly bluish or grayish in color, less commonly, pale reddish or liver-colored. It is very fine grained, highly plastic and tenacious, and thus contrasts strongly with the matter in which it is imbedded. The layers are rarely over a foot thick, and sometimes occur at short intervals apart, separated by the pebbly grit. They then often show the curious features of inclining at various angles toward each other, and of being cut off abruptly by the coarse matter. A seam of clay will thus sometimes abut against a nest of stones. In one place I saw three such short layers diverging from one extremity (where, however, they were not united) like the fingers of a hand, and ending abruptly in the normal pebbly grit. They do not usually extend horizontally more than twenty or thirty feet.

With these clay seams we often find rolled masses of similar matter, which sometimes have the diameter of four or five feet. These balls are enveloped in the grit, and commonly are attended with large Potsdam stones. The balls are plainly produced by the tearing up of the clay immediately after deposition. Sometimes a portion of a clay bed will be cut away by the eroding force, and rolled some distance and then covered by the floods of sandy matter carried forward by the agent which produced the erosion. These clays must have been brought from a very different source from that which yielded the coarse matter, and they seem to have been laid down on the irregular and shifting surface of the grit in pauses of the action of the force which produced this latter, hence the irregular inclination and local development of the clays. A renewal of the action of the powerful force which was involved in the transport of the coarser matters, would cut away and bury the clays. I do not find in place, any deposit which by its erosion could have yielded these clays. Their composition and character is just that of the thoroughly decomposed and slowly accumulated matter from granite and gneiss. I am strongly inclined to the opinion that they represent marshes within the Azoic area, which were swept away in the general and extensive erosion of its surface which took place at this time. This clay is of special importance as it contains the plants to be mentioned farther on. Besides well-preserved plants, it contains much lignite and comminuted vegetable matter which gives it often a dark color. The plants are all drifted apparently from some distance, and but a small number are well enough preserved to be determined. The texture of the clay is so close that sometimes the entire substance of the plant is preserved.

The summit of the grit is sometimes partly laminated and contains occasionally a layer of clay, as if a pause in the sedimentation had taken place for a short time. On this, or on the summit of the grit, there occurs very generally, but not always, a very remarkable bed of stones packed in grit like that of the mass on which it rests. This latter is more or less eroded and trenched. This bed of stones is, I think, the representative of the surface stones mentioned above as occurring in the Fredericksburg Belt. It represents a force which swept over the Azoic on the west, as well as over the Mesozoic here, and in the Richmond Belt. It seems to have been the closing deposit of the Mesozoic series in these border belts for it is followed by the Eocene strata.

These stones form a most heterogeneous mass, a true drift deposit. The mass is of varying thickness, usually six to ten feet. Sometimes, however, it thickens up to fifteen or more feet and thins down to three or four, or disappears. The material is a mixture of gravel, large rounded stones, and more or less angular and large masses. The rounded stones are mostly Potsdam, usually four to six inches in diameter or under, but quite often one and two feet. The smaller stones are well rounded, the larger are sub-angular but still quite smooth. They often show Scolithus markings. Mingled with these, usually occurring at the top of the bed, we find the large blocks which are of Azoic rocks, and include varieties found at various points to the west as far as the Blue Ridge. It is noteworthy that this is the only horizon in the Mesozoic here, which shows any coarse matter but quartz, which would be furnished by the Azoic. The most numerous of the masses and the largest, are furnished by the granites and gneisses west of Richmond. Blocks of these, three to four feet in diameter are common, but sometimes they are ten and twelve feet. These are usually more or less abraded. Gneiss and mica schist from farther west occur in large slabs, sometimes showing but little wear. Some vein quartz from the Azoic, and fragments of the sandstones of the Richmond Coal field are seen, but not commonly. Masses of the peculiar chloritic and other schists of the Blue Ridge far to the west, are not rare. These often attain the dimensions of three or four feet, and are commonly but little abraded. None of these stones or those of the Fredericksburg

Belt, show glacial striæ, but some of them show a mode of wear and polish highly suggestive of ice action. Indeed it is not probable that these fragments would show striations even if they had been imbedded in ice moving over the land, for the surface was no doubt too deeply decayed, and in too incoherent a condition to produce scratches.

Besides the Potsdam, we find other material which has been brought from west of the Blue Ridge. Slabs of the characteristic fossiliferous layers of the Chemung occur, but rarely however. They contain impressions of the stems of Chemung Crinoids.

Fossil Plants.—Though the clays are full of vegetable matter, it is only locally, and in very restricted layers, that we find determinable plants. These are very interesting and sometimes beautifully preserved. They consist of Conifers, Ferns and Cycads. The Conifers sometimes retain their cones. They belong to several species, among which we may mention a plant very close to, if not identical with, *Widdringtonites Haidingeri* Etting., a Wealden species. Another is very near to or identical with, *Araucarites curvifolius* Etting., also a Wealden plant. The ferns and a Jeanpaulia, have a decided Wealden facies. But the most abundant and characteristic plant of the beds is a fossil identical with that fine Cycad, *Pterophyllum* (*Dionites* of Schimper) *Buchianum* Etting., which is a species of the Wealden of Germany. This exists in immense numbers, and shows compound leaves two feet long. I observed, imbedded in the grit composing the bank of the canal at Dutch Gap, a coniferous tree which in the part projecting from the earth is eighteen inches in diameter. Forty feet are said to have been cut off from it in opening and widening the canal. It is merely browned and does not yet seem to have reached the stage of true lignite. The wood seems to be like that of *Pinus strobus*, and shows the annual rings distinctly. It may be worked with tools, not having wholly lost its coherence. The grit contains only lignitic and silicified wood. Taken as a whole, the plants are decidedly Wealden. I did not see a single species similar to those of the Richmond coal field, though several seem identical with Fredericksburg species.

Surface deposits of the Azoic.—If we ascend from the river to the top of the hills near Dutch Gap, we find ourselves on an undulating plain, composed of Tertiary sands and clays, and possibly later beds. We observe no drift matter on this surface. If however we proceed westward, we find the Tertiary accompanying us until we approach the Azoic border, and still without surface drift. But in the vicinity of the Azoic, where the Mesozoic crops out from under the Tertiary, we find the Potsdam stones, Azoic erratics, fragments of Mesozoic sandstones, etc., quite abundant, lying scattered over the surface. Passing still farther west, we find the same material with the fragments of the Richmond coal rocks becoming more abundant, and when we pass west of this field these coal rocks disappear, but we still have the other material. The Potsdam stones however do not pass westward over the whole Azoic area. They become confined to a belt along the James, in the upper course of that river. I do not know what is their disposition on the Upper Appomatox, as I have not examined the country in that quarter. It is plain that this coarse drift is the product of the same force which formed the uppermost bed of the Mesozoic at Dutch Gap.

The belt of Azoic, with the included Richmond belt of the Mesozoic, which contains on its surface Potsdam stones mingled with the fragments of Azoic rocks, is about twenty-five miles wide south of the James. It narrows to ten or twelve miles near the northern end of the Petersburg Belt, on the North Anna. West of this the Azoic drift masses are still found on the surface, up to the Catoctin Mountains but no Potsdam stones. It is noteworthy that this drift is usually almost entirely quartz, often in blocks two and three feet thick, representing the quartz of the veins so common in some of the Azoic strata. The reason why we do not find more of the crystalline schists is, because the deep decay which had affected these rocks at the time of their erosion, presented to the eroding agent only friable grits and clays with the quartz veins in them standing in their original position.

In the more westerly localities where the Potsdam is no longer found generally over the surface, I noticed that the bands of these Potsdam stones along the James do not follow the present windings of the stream but pass directly across the bends. They occur 150 to 200 feet above the river, and lie on the general level of the adjoining country.

The drift matter in the vicinity of the border belts, within the limits containing the Potsdam stones, covers the surface of the Azoic with a pretty continuous layer. But portions of it seem to be thicker than the general mass, corresponding to belts which were more deeply scored by the eroding agent. These have a direction a little north of west and south of east, showing the direction from which the eroding agent came. Sometimes, however, modern surface or stream erosion has so arranged these drift matters, as to cause them to appear to come from some other quarter than the west, which is their true source. This has misled Mr. R. P. Stevens, who visited the Richmond Coal-field some years ago, and came to the conclusion that the mode of transport was the movement of a glacier from the northward, in the Glacial Period. He states his views in a letter published in this Journal, Nov., 1873.

Professor Wm. B. Rogers, in an article entitled the "Gravel and Cobblestone Deposits of Virginia, and the Middle States," published in the Proc. Boston Soc. Nat. Hist., 1875, gives some account of the drift matter seen at Richmond, Alexandria, Washington, etc. Not having traced this material away from the vicinity of the James and Potomac, and finding it resting on the Tertiary, he was disposed to attribute its transport to the work of these streams in the Glacial Period, aided by the action of ice. While I think that most of this matter is of older date, yet I am convinced that considerable additions to that lying at the lower levels were made in the Glacial Period. I find drift matter on the Potomac, the James, and the Roanoke, which I think was brought during the Glacial Period, but this does not rise more than about sixty feet above the present water level. There is a great deal of drift along all these streams at that height, especially on the Roanoke.

The last of the surface deposits on the Azoic which are of importance are certain clays which are the most widely diffused of all. Thus we find them over the surface of the Azoic everywhere, to the west of the Petersburg Belt as far as the Catoctin and the Blue Ridge. They are not continuous but rather form irregular sheets. I cannot assert that these clays occur to the west of the northern end of the Fredericksburg belt, or that the Azoic drift in that quarter extends far westward of the eastern edge of the Azoic, as I have not made any extended examination there, but so far as I have examined, the condition of the surface is much as it is west of the Petersburg Belt. These clays are the only transported matter that I observed in the southern part of the State, in Pittsylvania County. Here they occur in the same way as in the northern district, now being described.

These clays are nearly always blood-red in color and rich in lime. They form a highly fertile subsoil, no matter on what sort of rock they may rest. They lie on all kinds of rocks, and are entirely independent of them. We find them on the gray grits of the Mesozoic; on the granite, with its surface decomposed to a white kaolinic grit, which shows the utmost possible contrast with the clays; or on mica-schists, etc. There is no rock east of the Blue Ridge rich enough in lime to yield these clays, except the epidotic schists, and hornblendic rocks which abound so between the Blue Ridge and the Catoctin. The clays contain decomposed fragments which resemble these strata, and when we can follow them, as we do up to these schists, we may conclude without hesitation that such is their origin. Hence they must have been transported in many cases, fifty or sixty miles. This however is not strange when we see that the Potsdam and other rocks from west of the Blue Ridge, must have often traveled 100 miles and more measured in an air-line, and much farther, if the course of the rivers crossing the Blue Ridge be followed. Professor Rogers in the old survey of the State, noticed these clays and expressed the belief that they must have been transported from the west.

They lie at the same horizon occupying the highest levels, and mark the plane to which the country was cut down at the close of the Jurassic. We accordingly find them in the hill-tops and over the intervals between the rivers. But owing to this high level, they are often removed by erosion. These clays are usually accompanied by the coarse drift. When this is present they either lie on the drift or contain it within their deposits. The latter position of the drift stones however is rare. The clays pass up to the edge of the Tertiary but not over on it. They are conspicuous on the granite near Richmond, which when the clay covering is removed, presents rounded and smoothed surfaces. These red clays generally are covered by a greater or less depth of gray soil, usually not over a few feet.

General remarks and Conclusions.—It is a noteworthy fact that the belts of Mesozoic which yield coal, contain it mainly at their southern or higher extremities. This is true of the Richmond Belt, of the Prince Edward Belt, and of the Pittsylvania Belt, which terminates in the Dan River coal field in North Carolina. This was perhaps caused by the fact that the southern ends of the Mesozoic areas, being higher, were better fitted for the formation of marshes.

I think that many of the features described in the preceding pages can best be explained by supposing that, in Triassic and Jurassic times, the Appalachian Mountain region was receiving supplies of snow too great to be removed by melting. Consequently the excess must have been discharged by glaciers. These must have advanced and receded more than once in the earlier periods, but did not penetrate to the sea. Toward the close of the Jurassic they advanced in such force that they reached the sea. In the intervening time, while the ice was gathering force, ice rafts, charged with stones and earth, floated down the streams which issued from the foot of the ice. To the frequent pushing forward, and consequent abrasion of the matter accumulated at the foot of the ice, and in the upper course of the rivers, we must attribute much of the rounded and polished condition of the Potsdam stones now found so far to the east of their original position. This ice may have made its final advance over the whole of the portion of the Atlantic slope in which the features above described are found, or it may have issued from the Blue Ridge, mainly along the line of the Potomac and James, and then in its farther advance to the east have spread laterally, so as near the border of the Azoic, to have coalesced into one sheet. The facts observed rather favor the latter method of advance. From this supposition it would follow that the Mesozoic areas were fed by the cold waters issuing from the ice and snow on the mountains. This may account for the paucity of animal life, especially Molluscan life, that they show. The only marine waters with which they could communicate contained forms that could not live in the cold inland waters.

It is probable that the courses of the present principal streams were marked out by this ice action, and hence come their direct course and independence of the character of the rocks over which they flow. There is no difficulty in explaining the growth of the plants, now found fossil, at a time when the Appalachian Mountain belt was covered with snow. All that was needed was a raising of the present winter temperature in the lowlands, for we shall show that for the formation of glaciers on the heights the climate need not have been colder than at present. Owing to the non-existence of the Rocky Mountains, the cold western and northwestern winter winds of the present time would not by reflection from that chain then reach the eastern slopes. At the same time the greater extension of the Gulf waters northward would cause southerly winds to sweep over these slopes. These winds passing over the cold waters of the lakes and great rivers would form abundant fogs. Thus a mild, equable, and moist climate would be produced in the lowlands, even if the earth had its present amount of cold, causing the growth of ferns, cycads, etc., and covering the hills with the immense growth of coniferous trees which we know must have existed. This condition of things would also have been eminently favorable for the production of coal. This was only brought to a close in the final advance of the ice at the end of the Jurassic Period, when all the abundant forms of plants of that period were extinguished to appear no more. No other cause seems adequate to explain the total extinction of the Jurassic flora, and the complete change which we find in the succeeding Cretaceous flora.

But while the plants were growing in the lowland and around the lakes, a very different condition of things prevailed in the high Appalachians. The stratigraphy of the formations composing this belt, and the amount of erosion which, as we know, took place, make it clear that in the early Mesozoic times much of this region must have stood above the snow line, and a still larger portion near it. If we recall the physical features of the North American continent which existed at that time, we shall see that even with our present climate then prevailing, the conditions would have been eminently favorable for the formation of glaciers. Along with a sufficient degree of cold we must have abundance of moisture to produce glaciers. This would be supplied by the western and southwestern winds. The latter would sweep unchecked from the Pacific over vast bodies of warm waters in the interior, and meeting the lofty mountain belt of the Appalachians, would give unlimited supplies of snow. The configuration of this elevated district, with its broad slopes, and long valleys inclining in one direction, would be eminently favorable for the collection of snow and its discharge in the form of glaciers. Indeed this region must at that time have formed a perpetual storm center. We are not without evidence, however, that a period of cold greater than that now existing, prevailed toward the close of the Jurassic, and in this we find the explanation of the advance of the ice so far to the east at that time.

Mr. Judd, in his excellent paper on the Secondary Rocks of Scotland, published in the Quar. Jour. Geol. Soc., vol. xxix, gives a description of certain very remarkable beds of stones, which under the name of the "Brecciated Beds of Ord," form the uppermost beds of the Upper Oolite of the east coast of Scotland. These beds are composed of huge masses of stones brought from a distance, and packed in fine argillaceous matter. The conditions are such that it is impossible for water alone to have transported the material. Hence some of the English geologists attribute this formation to ice action. The beds of stone are interstratified with shale beds, containing a beautiful Oolitic flora. Many of the features seen here resemble those of the beds at Dutch Gap. The question suggests itself whether at the close of the Jurassic an ice sheet did not cover the northern part of Scotland, extending east and west. If so, we may have in the melting of this ice, the source of supply of those waters which formed the fresh water Wealden deposits of England and northwestern Germany. It is well known that it is a puzzle to determine whence the great rivers which fed these lakes could have derived their abundant waters.

Another question may be asked. Is it not possible that some of the drift of our northern States, which is attributed entirely to the action of forces in the Glacial Period, may be much older? It is well known that none of the Mesozoic areas of the Atlantic slope seem to have had perfect communication with the sea. May not this be due, at least in the latest formed of them, to the great quantity of drift matter accumulated seaward, and not in all cases to an elevation of the coast?

The question whether drift deposits, similar to those of Virginia, may or may not be found in the States lying around the southern prolongation of the Appalachian belt, is worthy of the attention of geologists. Sir Charles Lyell, in his account of his second journey to the United States, mentions some significant features, which in Georgia and Alabama, attracted his attention on the line of meeting of the Tertiary and Azoic. He mentions seeing erratic masses of various sizes and character, which rest on the Azoic, pass up to the Tertiary, but do not pass over on the latter. He noticed this drift as resembling the northern Glacial Drift. If this is of Upper Jurassic age, then it ought not to pass over the Tertiary but under it. Again, he mentions seeing in Alabama, at the base of the Cretaceous, "dense masses of shingle perfectly loose and unconsolidated, derived from the waste of Paleozoic strata, a mass in no way except by its position, distinguishable from ordinary alluvium."

Tuomey mentions at Aiken, in South Carolina, beds of gravel and sand, without fossils, and lying at or under the base of the Cretaceous. Lieutenant Vogdes thinks that these may be Wealden.

Morgantown, West Virginia, Nov. 4, 1878.

ART. XXIX.—*Notice of recent Additions to the Marine Fauna of the eastern coast of North America, No.* 3; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XL.*

AMONG the many interesting additions recently made to the American marine fauna, are two handsome undescribed species of "sea-feathers" (Pennatulaceæ) and three fine new species of hydroids, belonging to the family Plumularidæ, of which only three species have previously been known to inhabit our northern coast. Those now added appear to belong to the genus *Cladocarpus*, recently established by Allman, for several deep-water forms, from the coasts of Europe and the Gulf of Mexico. Two very interesting Cephalopods have also been recently added to our fauna.

ANTHOZOA.

Virgularia grandiflora, sp. nov.

A large, stout species, with very large polyps, which are only slightly united, close to their bases. Rachis stout, ventral side convex, and with a wide naked space; below the polypiferous portion there is a marked fusiform swelling, with longitudinal wrinkles; the end is bulbous and perforated; at the distal end the naked rachis extends about 8^{mm} beyond the last polyp-cells, and tapers to a blunt tip. Axis rather stout, rounded, yellowish white. The polyp-cells are large, and arranged in very oblique, rather irregular rows, seldom containing more than six or eight, and separate so nearly to the

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*** Nos. XXXVII and XXXVIII were, by an error, doubly employed in this series. This is, in reality, the forty-second article.**

base that they form only very rudimentary alæ, while in some states of contraction they appear entirely disunited. The rows are rather distant on the same side, and on opposite sides alternate irregularly, and the dorsal members of adjacent rows intermingle or overlap, while the polyps in the middle region usually stand alternately farther forward and farther back in the same row, while the most ventral one is usually placed farther toward the ventral side in each alternate row; the polyp-cells are stout, cylindrical, soft, slightly eight-ribbed, considerably contractile. Tentacles, very long, tapering to a long slender tip, with very numerous, slender lateral lobes. Most of the polyps are well expanded; a very few have the tentacles nearly retracted. Zoöids are numerous, small, but very distinct, covering the lateral intervals between the rows of polyps and usually extending into the intervals between their bases, while along the ventral side the lateral patches are usually connected by a belt of zoöids running outside of the most ventral polyp-cells, but those of the latter that stand out more than usual, usually interrupt these belts. No calcareous spicula were found in the polyps or cœnenchyma. Color of the rachis and polyp-cells brownish yellow, in alcohol; tentacles dark brownish red.

Length, 350^{mm}; of naked peduncle, 60^{mm}; diameter of bulb of latter, 10^{mm}; of narrow portion, 5^{mm}; of rachis, 5 to 8^{mm}; of axis, $1{\cdot}5^{mm}$; diameter of largest polyp-cells, 3^{mm}; their length, 5^{mm}; length of tentacles, 6 to 7^{mm} or more.

Taken on a trawl line, in 220 to 260 fathoms, lat. 42° 46′; long. 63° 45′, by the crew of the schooner "Laura Nelson," Capt. R. N. Morrison. This is a very handsome and remarkable species, of which only a single specimen has been obtained. It differs widely from the previously described species of *Virgularia*, and approaches Kölliker's genus *Halipteris*, in appearance, but differs in the character of the polyp-cells and in the absence of spicula.

Funiculina armata, sp. nov.

A long, slender species, with large, rigid, urceolate, spiculose polyp-cells, armed at the aperture with eight, sharp, divergent spiculose points. Axis and rachis quadrangular, slender, the sides of the axis concave. The polyp-cells are entirely separate and arranged in numerous irregular transverse clusters of two to four, smaller and larger intermingled: they are so stiffened by spicula as to be scarcely flexible, and retain well their form: they are elongated, swelling out gradually from near the base and tapering again, above the middle, to near the summit, which suddenly expands to the edge, from whence eight, long, acute, rigid, white points diverge; tentacles spiculose, but wholly retractile within the cells. Among the oridary cells are small clusters of much smaller zoöids, which are white, prominent, larger at summit than at base, and possess eight rudimentary tentacles. The polyp-cells are filled with long, slender, smooth, triquetral, or three-winged, prismatic spicula, arranged in longitudinal bands and irregular transverse clusters, while a convergent cluster forms each of the eight points at the summit; similar, but smaller, spicula occur in the main stem of the tentacles. The ova are large and situated both in the polyp-cells and in the cavity below their bases, where a considerable cluster can be seen when, as often happens, the cells are broken off. Rachis yellowish white below, light orange-brown above; polyp-cells darker brown, with white spicula; tentacles dark brownish red.

Height, 600^{mm}; diameter of rachis near base, 1·5^{mm}; in middle, about 1^{mm} to 1·5^{mm}; length of larger polyp-cells, about 6^{mm}; diameter, 1·5 to 1·75^{mm}.

Taken on a trawl-line in 300 to 400 fathoms, about forty miles southwest from the N.W. Light of Sable Island, N. S., by George K. Allen, schooner "M. H. Perkins."

Ptilella borealis Gray = ***Pennatula borealis*** Sars = ***Pennatula grandis*** Ehr. (*non* Pallas) = ***Ptilella grandis*** Kor. & Dan.

Several additional specimens of this species have been received from off Nova Scotia.

In the Fauna Litt. Norvegiæ, vol. iii, p. 82, 1877, Koren and Danielssen have given an elaborate description of this species, with figures. They have shown good reasons, apparently, for adopting Gray's genus, *Ptilella*, for this form, but inasmuch as Ehrenberg's name (*P. grandis*) had been preoccupied, it ought not to be used for this species.

CEPHALOPODA.

Histioteuthis Collinsii, sp. nov.

A very large and handsome species, with a broad thin web, extending between and nearly to the ends of the six upper arms. Tentacular arms about two feet long and slender, expanding near the end into a broad, long-oval, sucker-bearing portion "or club," which is bordered by a membrane, widest on the outer edge; it ends in a tapering tip, on the back of which there is a thin crest-like membrane or keel, enlarging backward to the end, where it forms a rounded lobe. The most expanded portion of the "club" bears five rows of suckers, with finely serrate rings; two rows contain much the largest suckers, four or five in each, the more central of the two rows containing four suckers larger than the rest; outside of these are two rows of medium-sized suckers, and along the inner edge of the club there is one partial row of similar ones, while along the inner edge of the proximal portion of the club there is a row of smooth-edged suckers, alternating with tubercles that fit into corresponding suckers on the other arm; a row of similar but smaller suckers extends for about six inches along the inner median line of the arm, alternating, two by two, or singly, with tubercles, and gradually becoming more distant. The tip of the arm, beyond the expanded club, bears minute serrate suckers, at first in six rows, decreasing to two at the end. Sessile arms stout, three-cornered, tapering to slender tips, each bearing two rows of globular suckers, having a small, oblique opening and few blunt teeth.

All the arms on the left side are an inch or more longer than the corresponding right ones. The dorsal and ventral arms, of the same side, are about equal, and decidedly shorter than the two lateral pairs, which differ but little in length. A broad, thin web, about two-thirds as broad as the length of the arms, unites the upper three pairs together, and as a narrowing border extends along their sides, nearly to the tips. The lower lateral arms have a thin, crest-like membrane on their outer, median surface, commencing at the basal fourth and extending nearly to the tips. The ventral arms are united together, near the base, by a web, which also unites to the main web, in the median plane. A narrow web, arising from the outer angles of the arms, also unites all the arms together for a short distance above their bases. Eyes mutilated, their lids form a large, simple, rounded opening. Beak with very sharp black tips; a broad membrane, rising into six prominent angles, surrounds the mouth. The outer surface of the head and arms is covered with large, very slightly raised warts or tubercles, which are dark blue with a whitish center; a circle of them surrounds the eye lids. Color, between the warts, purplish brown, with dark brown spots, and reddish specks; web and inner surface of arms uniform dark reddish brown; suckers yellowish white; tentacular arms light orange-brown.

Tentacular arms 24 and 25 inches long; diameter at base, ·5; breadth of club, ·70, without membrane; its length, 2·75; length of the slender tip, 1·25; of dorsal crest, 1·5; length of dorsal arm, of left side, 14 inches; 1st lateral, 17; 2d lateral, 17·25; of dorsal, 14·25; breadth of lateral arms, at base, ·9; thickness, ·75; diameter of eye-opening, ·9; diameter of head, at base of arms, 3·5.

Taken from the stomach of *Alepidosaurus*, lat. 42° 49′, long. 62° 57′, off Nova Scotia, by the crew of the schooner "Marion," Capt. J. W. Collins.

All parts back of the eyes are absent, the eyes are mutilated, but the specimen is otherwise in excellent preservation, even the thin web and the colors being uninjured. With it was the terminal portion of an arm of a gigantic squid (*Architeuthis*), too much injured for specific determination. I have named the species in honor of Capt. Collins, to whom and the crew of his vessel, we are indebted for so many interesting and novel specimens.

Taonius hyperboreus Steenst. (?)

A large and handsome species of this genus has just been received, which may be this species, though in its proportions differing from Steenstrup's measurements. The eyes are very large and globular, in contact, beneath the head. The arms are very short, and part of them have lost their tips and afterwards healed. The tail is long, lanceolate, tapering to a very long, slender, acute tip. Color brownish red, with rather large rounded, dark brown spots. Length of head and body, 13·5 inches; edge of mantle to tip of tail, 12; tail, 5; its breadth, 1·8; diameter of body, 2·25; of eye, 1; length of ventral arms, 1·9; of lower lateral arms, 2·25.

Taken at the surface, in the northern edge of the Gulf Stream, W. long. 55°, by Mr. Thomas Lee, schooner "Wm. H. Oaks," Jan., 1879.

ART. XXX.—*Note on the Age of the Laramie Group or Rocky Mountain Lignitic Formation*; by H. M. BANNISTER.

IN his recently issued report on Systematic Geology, vol. i, U. S. Geological Exploration of the 40th Parallel, Mr. Clarence King discusses at length the disputed question of the age of the Rocky Mountain lignite series, to which, by agreement with Dr. Hayden, he gives the name of the Laramie group. In his argument for the exclusively Cretaceous age of these beds, it appears to me that he has generalized too freely, and I propose to notice a few omissions and points where he seems to me to be in error.

We may leave aside all the paleontological evidence of the age of these beds, the general Eocene aspect of their invertebrate fauna, which, I believe, no one has disputed, the Tertiary *facies* of the flora, which, I believe, is an issue between Professors Lesquereux and Newberry, and the Cretaceous Saurians found high up in the series, as all compatible with the theory of its transition character, and the question of its conformability remains. Mr. King asserts that it is absolutely unconformable with the overlying Vermilion Creek group, and that nowhere, save in one locality, is there any appearance of conformability between the two. I should hesitate to disagree with him, were it not that when examining this formation with the late Mr. F. B. Meek, in the year 1872, we both thought we found evidences of conformability between these strata and the overlying Tertiary in other localities than Black Buttes, the one admitted by Mr. King. Then, in examining the reports of other geologists who have visited the region, I find that their observations in these localities, as far as stated, agreed with ours. Among these I may perhaps include Mr. King himself. He says (p. 334), "Good exposures of the Laramie group beds may be seen along the railroad, just east of Separation station, where they show the peculiar ashen gray sandstones, containing a considerable development of argillaceous beds, and a great number of coal seams, and contain plentiful plant remains, generally as leaf-impressions, and frequently also as indistinct and partially carbonized stems in the impure sandstones. In the ridge south of this station, they dip at an angle of 10° north, but flatten out to the north, so *that the line between them and the overlying Tertiaries is even more difficult to determine* than the exact division between them and the underlying Fox Hills group." (Italics mine.) Now, at this locality, Mr. Meek and I examined a thickness (estimated) of eighteen hundred feet or more of conformable beds, and in the upper portion found abundance of purely fresh-water shells, and a fragment of bone, apparently of a turtle. At the base of this series was a heavily bedded sandstone, exactly similar to that which forms the only constant horizon at Black Buttes, and the overlying strata were not dissimilar to those at the latter locality.

In the report on Descriptive Geology of the same survey, Mr. Emmons, Mr. King's assistant, when speaking of this same region, uses the following words (p. 207, vol. ii, U. S. Geol. Expl. 40th Parallel): "To the west of Rawling's Peak, as we have seen, the Cretaceous strata fall off with an ever decreasing angle of dip, assuming to the north of the railroad, between Separation and Washakie, an almost horizontal position, and are gradually succeeded by the overlying, and, in this region, conformable beds of the Vermilion Creek Tertiary." This passage sufficiently indicates that the conformability of the strata is not merely local; and that it is also not local at Black Buttes, is proven by the testimony of Professor Cope, who found it to exist for miles south of the station, while our observations were made to the north. Thus we have a conformability, as far as observed, on both sides of the Washakie Tertiary basin, according to the testimony of Mr. King's own survey.

Passing to the westward, we find Mr. King speaking as follows in regard to the Evanston coal-bearing strata which, by Mr. Meek and myself, had been regarded as of uncertain but probably of Tertiary age. "At Evanston the highest portions of the Laramie Cretaceous are not exposed, but the sandstones near the summit of the group contain the enormous workable coal-beds of the Rocky Mountains and Wyoming Coal Companies. These coal-bearing Laramie beds dip at angles from 16° to 25°, whereas the Vermilion Creek Tertiaries are nearly horizontal over them, and carry remains of the genera *Coryphodon* and *Eohippus* and fishes." Mr. Emmons says, speaking of the same beds, that there is no doubt but that they belong to the Cretaceous and probably to the Laramie group, though, from the lack of paleontological evidence, this reference is simply conjectural. Now, so far as I can learn, not a single salt- or brackish-water fossil has been found at this locality, though land and fresh-water shells are abundant in strata immediately above the coal, the flora is said to be Tertiary, and in these same dipping beds—not in the nearly horizontal ones mentioned by Mr. King—Professor Cope found an Eocene vertebrate fauna, identifiable with that of the lower Green River epoch (Vermilion Creek Tertiary.) Moreover, if the coal is near the top of the Laramie series, which here, according to Mr. King, dips unconformably under the Tertiary, what are we to do with over twenty-four hundred feet of strata overlying it conformably and of which a section was taken by Mr. Meek and myself? As a detailed section it is of no special value, the strata vary sometimes within a very short distance, but its vertical extent is of interest in this connection. It is highly probable that it includes the horizon of the limestone bed with vertebrate remains discovered by Professor Cope, which was possibly only local; such beds sometimes run out in a few rods or yards. A comparison of the lower part of the section made at Almy, by Mr. Meek and myself (p. 540, Hayden's Annual Report for 1872) and one including the same horizons also made at Almy, which is given by Professor Lesquereux, on page 338 of the same volume, will sufficiently illustrate this fact. The sandstones, indeed, often suggested beach deposits rather than regularly deposited strata.

That these Laramie beds and the overlying Tertiaries are often unconformable may be readily admitted without invalidating the hypothesis of their transition character. They are sometimes unconformable in themselves; an apparent nonconformity was noted just below the horizon of Black Buttes, and another, many hundred feet lower down, has been made the dividing line between the Tertiary and Cretaceous by Major Powell and Dr. White. The evidence appears to me to indicate that the Laramie epoch was throughout one of stratigraphic disturbance rather than that there was only one great orographic change at its close, and that the reasonableness of the opinion of its transition character is not yet altogether disproved.

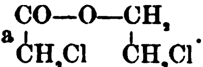
SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Gelatinous Silica and on an Inorganic membrane formed of it.*—Ullik has experimented on gelatinous silica and has prepared it in such form as to be used in dialysis. The transparent jelly which is obtained when a dilute solution of water glass is poured into hydrochloric acid, is well known. The author has succeeded in washing it absolutely free from sodium chloride and the excess of acid, and in producing pure silicic acid as a perfectly transparent jelly. In the air it dries to a transparent mass, about one-fifth in volume, breaking into fragments resembling hyalite, and pretty hard. Four decigrams of the dry mass gave when evaporated with hydrogen fluoride, a residue of only 0·0016 gram. It corresponds nearly to the formula H_2SiO_3. Suddenly ignited, it gives a brilliant sand; but heated with care, the temperature rising very gradually, up to full ignition, it retains its form and glassy transparent masses are obtained. The dried has a sp. gr. of 1·84 to 1·907, resembling opal; the ignited, of 2·322 to 2·324, which is that of tridymite. The facility with which the gelatinous silica was washed led the author to conclude that diffusion had taken place through it and hence that it possessed the properties of a membrane. To prove this definitely, the bottom was cracked out of a precipitating glass, the edges pressed down upon a piece of rubber covered with filter paper, and the mixture poured in. After solidification of the silicic acid, the whole was immersed in water, the filter paper removed, and the gelatinous mass washed by repeated renewal of the water. In this way a dialyser was made whose mouth was closed completely by a membrane of silicic acid three millimeters thick. A second one had a membrane half a millimeter thick, supported by paper. Experiment proved that no filtration took place through these membranes, but that they allowed diffusion to go on readily. For example, 50 cm. of a 20 per cent sugar solution being placed in the dialyser, it being immersed in water until the level was the same within and without, there was produced in three days a difference of level of 12 mm. with the thicker, and 20 mm. with the thinner membrane; and there had passed out into the water 14 per cent of the sugar in the former case and 49·5 per cent in the latter. A membrane made in a funnel tube, and this filled with copper sulphate solution and placed in water, showed after twenty-four hours a difference of level of 13 cm. and the water without was distinctly blue.—*Ber. Berl. Chem. Ges.*, xi, 2124, Dec. 1878. G. F. B.

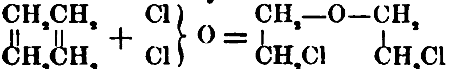
2. *On the Action of Hypo-chlorous oxide on Ethylene.*—Mulder and Bremer have studied the action of hypochlorous oxide upon ethylene. A flask filled with fragments of pyrolusite was heated on the water-bath, and strong hydrochloric acid dropped upon it through a syphon. The chlorine thus evolved was con-

ducted through three wide glass tubes each of one-half a liter capacity, containing equal weights of pounded glass and of mercuric oxide, and heated in a sandbath to about 340°. The hypochlorous oxide thus produced was mixed with dry ethylene gas in excess and passed upward through a vertical tube cooled by water and protected from the light. A liquid condensed in the tube which afforded on fractioning a small quantity of ethylene chloride boiling below 100°, but consisted chiefly of a product boiling at 180°-210°, and having a vapor density of 73·8. Analysis gave its empirical composition as $C_4H_6Cl_2O_2$. Fractionated in vacuo, a purer product was obtained. Heated with silver oxide, the filtrate afforded a salt which proved to be silver monochloracetate $CH_2Cl{-}COOAg$. Heated with water (in which it is not soluble) with an upward condenser, monochloracetic acid was again obtained. After neutralizing the liquid with potassium carbonate, ether extracted from the liquid monochlorhydrin $CH_2Cl{-}CH_2OH$, boiling at 130°. Hence the action described affords a body having the structural formula



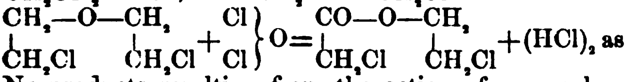
$$\begin{array}{lll} CO & {-}O{-} & CH_2 \\ | & & | \\ CH_2Cl & & CH_2Cl \end{array}.$$

The reaction by which this monochlorethyl monochloracetate is produced is



$$\begin{array}{ll} CH_2 & CH_2 \\ \| & \| \\ CH_2 & CH_2 \end{array} + \left.\begin{array}{l} Cl \\ Cl \end{array}\right\} O = \begin{array}{lll} CH_2 & {-}O{-} & CH_2 \\ | & & | \\ CH_2Cl & & CH_2Cl \end{array}$$

as the first stage; and



$$\begin{array}{lll} CH_2 & {-}O{-} & CH_2 \\ | & & | \\ CH_2Cl & & CH_2Cl \end{array} + \left.\begin{array}{l} Cl \\ Cl \end{array}\right\} O = \begin{array}{lll} CO & {-}O{-} & CH_2 \\ | & & | \\ CH_2Cl & & CH_2Cl \end{array} + (HCl)_2$$

as the second. No products resulting from the action of one molecule of hypochlorous oxide upon one of ethylene appear to be formed.—*Ber. Berl. Chem. Ges.*, xi, 1958, Nov. 1878. G. F. B.

3. *On the Hydrogenation of Benzene.*—The tendency in some quarters to consider benzene as a final hydrocarbon, in consequence of its being the nucleus of the aromatic series, has led **Berthelot** to investigate the action described several years ago by him, by which any unsaturated hydrocarbon may be converted into a saturated one. The method consists simply in treating the hydrocarbon with a saturated solution of hydriodic acid at a temperature of 275° to 280° for some time. In the new experiments, several tubes, each containing 20 c.c. of saturated hydriodic acid and 0·6 c.c. of benzene, were sealed and heated to 270° for twenty hours. The unaltered benzene was removed by fuming nitric acid, and the remaining hydrocarbon, about two thirds of the whole, rectified and analyzed. It was a mixture of C_6H_{10} and C_6H_{12}. A second treatment with hydriodic acid gave nearly pure C_6H_{12}. A third gave a mixture of C_6H_{12} and C_6H_{14}. And finally a fourth treatment gave C_6H_{14} boiling between 68·5° and 70°. This is the final term identical from both the aromatic and the fatty series, the only completely saturated hydrocarbon containing six atoms of hydrogen.—*Ann. Chim. Phys.*, V, xv, 150, Oct. 1878. G. F. B.

4. *On the Action of Hypobromous acid on Ethylene dibromide.*—**Demole** has been led by theoretical views to study the action

of hypobromous acid on ethylene dibromide. This latter body treated with a strong solution of the acid in excess and agitated for an hour, gave an oily liquid and a supernatant liquid colored by bromine. The latter on examination afforded bromacetic acid. The oil heated in a watch glass for four or five hours, crystallized on cooling, the mass being purified by crystallization from boiling alcohol. It then gave the formula $C_4H_2Br_6O$, and this by its reactions was proved to be an acetone, having its oxygen joined to the carbon by two bonds. On reduction with sodium amalgam, ethyl-methyl-acetone C_4H_8O was obtained, which gave a crystalline compound with hydrosodium sulphite. Hence the first body was hexabrom-ethyl-methyl-acetone. Oxidized with fuming nitric acid, it yielded malonic acid, easily determined from its properties and those of its barium salt. This shows the structure of the hexabrom-ethyl-methyl-acetone to be $CBr_3—CO—CH_2—CBr_3$, the terminal carbon atoms having all the bromine.—*Bull. Soc. Ch.*, II, xxx, 482, Dec. 1878. G. F. B.

5. *Relative Affinities of Oxygen and the Haloid Elements.*—In the October number of the Annales de Chimie et de Physique, Berthelot has a very interesting article on the Relative Affinities and Power of Replacement of Oxygen and the Haloid Elements, and shows that the order of affinity and replacement can be predicted from the amount of heat evolved in the production of the various binary compounds, of which the metals and the metalloids form with oxygen on the one part, and with chlorine, bromine or iodine on the other. In the case of the metals the heat evolved by union with oxygen is with a few exceptions less than that resulting from the union of the same metal with either of the three haloid elements mentioned, and it is shown that in the same measure oxygen may be replaced by the direct action of these elementary substances on the oxides; and further that, in the exceptional cases presented by certain compounds of iodine, where the thermal relations are reversed, the order of affinities—as shown by the replacing power—is reversed as well. Moreover a few other apparent exceptions to the general rule are shown to result from the formation of intermediate products.

While, however, the heat evolved by the combination of the metals with oxygen is less than that resulting from the formation of the corresponding haloid salts, these conditions are, as a rule, reversed in the case of the compounds of the metalloids with the same elements, and so the order of replacement is reversed as well. This is shown to be true in regard to the compounds of phosphorus, arsenic, silicon and boron, and moreover it is made evident that certain anomalies, depending on the production of oxichlorides, are really confirmations of this law of thermo-chemistry, which Berthelot has done so much to establish. The paper is one of great interest, and contains besides the illustration of the important general principle we have stated, the experimental evidence of a large number of new thermo-chemical data. Especially worthy of notice is a new general method of thermo-chemistry applied to the determination of the heat of combination of bromide of aluminum, that of chloride of aluminum being known. Thus Al_2Cl_6 is dissolved in water containing 6KBr, and on the other hand Al_2Br_6 is dissolved in the same amount of water containing 6KCl. The difference between the quantities of heat evolved in the two cases gives the only element wanting for calculating exactly the difference between the amounts of heat evolved in the formation of the two anhydrous compounds. Thus

We know from previous investigations that $3(K_2+Br_2$ (gas)+water$)=6KBr+$Aq. yield	+285·0 units.
We find by experiment at this time that Al_2Cl_6 dissolved in the previous solution yield	+ 76·0 "
Representing the heat resulting from the union of $Al_2+Cl_6=Al_2Cl_6$ by	x
We have for $Al_2Cl_6+6KBr+$Aq.	$x+361·0$ "
So also we know that $3(K_2+Cl_2+\text{water})=6KCl+$ Aq. yield	+302·4 "
And we find as before that Al_2Br_6 dissolved in this product yields	+ 86·9 "
Representing the heat-form $Al_2+Br_6=Al_2Br_6$ by	y
We have for $Al_2Br_6+6KCl+$Aq.	$y+389.3$ "

Since the final states of the two resulting solutions seem absolutely the same, it must be that

$$x+361·0=y+389·3$$

$$\text{or } x-y=389·3-361·0=28·3 \text{ units.}$$

If then we adopt for x (when $Al_2+Cl_6=Al_2Cl_6$) +160·9
We have for y (when $Al_2+Br_6=Al_2Br_6$) +132·6

J. P. C.

6. *The Part of Acids in Etherification.*—The effect of the presence, merely, of an inorganic acid in determining the etherification of alcohols by the organic acid has long been known, and the theories advanced to explain this so-called "catalytic" action have been numerous. In a paper following the last, Berthelot seeks to show that these processes also conform to the general "law of maximum works," that is, are the natural result of a tendency to a condition, in which the maximum amount of heat is evolved. To this end both the chemical, and the thermal conditions, involved in both the separate and also the mutual action of hydrochloric and acetic acids on alcohol are fully discussed, and it is shown that in the last case the formation of acetic ether is attended with a much greater evolution of heat than would be that of hydrochloric ether. Hence when the two acids are present, the former and not the latter of these two ethers is the chief product of the reaction, and it is shown that the one condition which chiefly determines the result is the great amount of heat evolved by the solution of HCl gas in an excess of alcohol. It is also shown that this thermal theory gives a satisfactory account of the well known conditions limiting these reactions, and that in the action of a mixture of strong nitric and sulphuric acids on hydrocarbon compounds, similar thermal relations determine the production of nitro- instead of sulpho-derivatives. J. P. C.

7. *Preliminary Note on the Substances which produce the Chromospheric Lines;** by J. NORMAN LOCKYER, F.R.S.—Hitherto, when observations have been made of the lines visible in the sun's chromosphere, by means of the method introduced by Janssen and myself in 1868, the idea has been that we witness in solar storms the ejection of vapors of metallic elements with which we are familiar from the photosphere.

A preliminary discussion of the vast store of observations recorded by the Italian astronomers (chief among them Prof. Tacchini), Prof. Young, and myself, has shown me that this view is in all probability unsound. The lines observed are in almost all cases what I have elsewhere termed and described as *basic lines;* of these I only need for the present refer to the following:

b_3 ascribed by Ångström and Kirchhoff to iron and nickel.
b_4 " " Ångström to magnesium and iron.
5268 by Ångström to cobalt and iron.
5269 " " calcium and iron.
5235 " " cobalt and iron.
5017 " " nickel.
4215 " " calcium, but to strontium by myself.
5416 an unnamed line.

Hence, following out the reasoning employed in my previous paper, the bright lines in the solar chromosphere are chiefly lines due to the not yet isolated bases of the so-called elements, and the solar phenomena in their totality are in all probability due to dissociation at the photospheric level, and association at higher levels. In this way the vertical currents in the solar atmosphere, both ascending and descending, intense absorption in sun-spots, their association with the faculæ, and the apparently continuous spectrum of the corona and its structure, find an easy solution.

We are yet as far as ever from a demonstration of the cause of the variation in the temperature of the sun; but the excess of so-called calcium with minimum sun-spots, and excess of so-called hydrogen with maximum sun-spots follow naturally from the hypothesis, and afford indications that the temperature of the hottest region in the sun closely approximates to that of the reversing layer in stars of the type of Sirius and α Lyræ.

If it be conceded that the existence of these lines in the chromosphere indicates the existence of basic molecules in the sun, it follows that as these lines are also seen generally in the spectra of two different metals in the electric arc, we must be dealing with the bases in the arc also.

8. *Upon the Nature of Spectra of Mixed Gases*—Prof. E. WIEDEMANN discusses at length the theories of the action of molecular forces in producing various spectra. Certain writers, among whom are Stefan and Van de Waals have supposed the existence of an attracting force between the molecules, and also a repulsive one arising from an ether envelope which surrounds the molecule. The rotation and oscillation of the atoms in the mole-

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* Paper read at the Royal Society, London.

cule, which increase to the point of breaking up the molecule into its atoms and which action increases with the temperature, may produce periodic vibrations in the surrounding light ether. Line spectra, on this theory, are produced when, under the influence of heat, the molecules are divided into atoms and an oscillatory vibration is set up. F. Lippich and Pfaundler have shown from a theoretical point of view that the broadening of line spectra may result from the influence of high temperature in producing a motion of the molecules of a gas partly toward and partly away from the observer. Wiedemann examines the views in regard to band spectra and concludes that they cannot be attributed to rotation of the molecules; and that the difference between band and line spectra is not explained on the hypothesis of a change of pressure of the gas under consideration. Wiedemann believes, after consideration of the facts, that the difference between emission and absorption spectra is to be sought in the change of vibration peculiar to each chemical combination, which vibration is modified by surrounding circumstances; and that two different substances can give identical spectra only when the forces acting between the atoms in the molecules are identical. Prof. Wiedemann states his intention to test his theoretical conclusions by experiment and give the results of his preliminary investigation upon the spectra of mixed gases. A Geissler tube containing a small portion of mercury was filled with hydrogen and the tube was heated in an air bath while the current from an induction apparatus passed through it. At ordinary temperatures the hydrogen spectrum was seen; with an increase of temperature appeared that of quicksilver. With increasing temperature the spectrum of the latter grew brighter and brighter, while that of hydrogen disappeared in all parts of the tube. In another trial, sodium was enclosed in hydrogen or nitrogen vapor. Here, also, the spectra of the gases disappeared and at a high temperature only the lines of sodium appeared. The author believes that the disappearance was not due to any new chemical combination into which the substances had entered, and discusses at some length the theory that the passage of electricity from molecule to molecule is to a certain degree selective and that it can call forth certain oscillations or vibrations in certain molecules of one substance while it cannot do so in a neighboring substance which forms a mixture with the first.—*Ann. der Phys. und Chem.*, No. 12, 1878, p. 500. J. T.

9. *The Law of the Telephone.*—M. HERMANN, in Archiv für Physiologie, vol, xvi, pp. 264 and 314, has adduced certain experiments to show that M. Dubois Reymond's theory that the action of the telephone can be explained from the general law of induction in which the bending of the iron plate is taken into account and the induction of the current path upon itself is neglected, does not explain the facts observed. Prof. H. F. Weber communicated to the Züricher Naturforschenden Gesellschaft, a paper in which he showed that Hermann's experiments agreed entirely

with the theoretical laws of induction, and that M. du Bois Reymond was wrong in neglecting the induction of the current path upon itself, which last was really the principal agent in producing the agreement between theory and practice. Ten days later M. Helmholtz presented a paper to the Berlin Akademie der Wissenschaften which covered the same ground as Prof. Weber's paper. The general results of these papers are as follows: (1.) "In the telephonic circuit the tone is in general altered." (2.) "The phase-displacement that occurs during the telphonic transit is not a constant quantity, its amount changes with the constitution of the path of the current, and depends on the number of vibrations." (3.) "In certain cases, however, the amplitude of the induced current becomes independent of the vibration number *n* and thus the tone of the exciting sound is unchanged." J. T.

II. GEOLOGY AND NATURAL HISTORY.

1. *Reports upon the Specimens obtained from borings made in* 1874, *between the Mississippi River and Lake Borgne, at the site proposed for an outlet for Flood Waters;* by Prof. EUGENE W. HILGARD and Dr. F. V. HOPKINS. With a letter of transmittal from Bvt. Maj. General G. K. WARREN, Major of Engineers, President of the Commission. Washington, 1878.—This memoir, of great interest geologically, is from the Supplement to the Report of the Commissioner of Engineers of January 16, 1875, on the Reclamation of the Alluvial Basin of the Mississippi.

Prof. Hilgard published, several years since (Rep. Chief of Engineers, U. S. A., 1870), an account of a section 146 feet deep, made in boring a well at New Orleans in 1856. In it, the part below a depth of 41 feet (numbered in the present pamphlet 1 to 4) was found to contain marine shells, and to consist, below the 112 feet level, of a drab or bluish clay (numbered 1), and (Nos. 2 to 4) marine sandy beds, excepting 3 feet of clay (No. 3); then, from 21 to 41 feet in depth, a blue fluvio-marine clay, here numbered 8; and, at top, 21 feet of fresh-water bluish tough clay, here numbered 11.

In the borings of 1874 referred to in the above title, the same beds were met with. No. 1 was reached in four of them at the depth of 91 to 97 feet, and No. 4, below 57 to 72 feet; both were found to contain numerous marine shells, while the thin clay bed No. 3, appeared to be a fluviatile stratum. No. 4 has afforded the shells *Balanus eburneus*, *Nassa acuta*, *Anachis avara*, *Oliva mutica*, *Utriculus* (*Tornatina*) *biplicatus* (*Bullina canaliculata* of Rep. of 1870), *Pholas costata*, *Pandora trilineata*, *Corbula cuneata*, *Mactra lateralis*, *Tellina alternata*, *T. tenera*, *T. tenta*, *Macoma fusca*, *Chione cancellata*, *Ch. cribraria*, *Dosinia discus*, *Lucina multilineata*, *L. costata*, *Arca transversa*, *Pecten dislocatus*, and other species.

No. 8 was met with in four borings near Lake Borgne between the upper levels 25 to 26 feet, and the lower 52 to 56 feet, in three others, between the levels 22 to 38 and 64 to 73 feet; and varying much in depth in others. This bed is a *blue delta clay*, the deposit of a tide-water marsh, containing no large marine shells, but an intermingling of marine and fresh-water microscopic forms, the latter increasing in number landward. The evidence shows that it was traversed by streams.

Above No. 8, the next marked beds are Nos. 11 and 12, of which No. 11 is a cypress-swamp deposit, and 12, a sea-marsh clay, both still in progress. Dr. Hopkins gives a list of the microscopic organisms of strata Nos. 8 and 12 with notes and figures, and points out the fact that there is a marked difference between them. Among the species in No. 8 there are *Grammostomum Americanum*, *Lenticulum discus*, *Rosalina Beccarii*, *Navicula Gundleri*, *Pinnularia viridis*, *Eunotia gibberula*, *Coscinodiscus radiatus*, *Leptocistinenia Kinahani*; and in No. 4, *Rotalia pachypleura*, *Planulina elegans*, *Navicula fulva*, *N. viridis*, species of *Rhizosolenia*, *Nitzschea*, *Globigerina*, etc. The two have in common *Orbulina universa*, *Melosira distans*, *Cocconema lanceolatum*, *Synedra acuta*. Prof. Hilgard remarks:

"Stratum 8 may be a true delta deposit of the present Mississippi, such as it has been since the re-elevation of the continent which determined the erosion of the present trough of the river. The fact that an apparently fluviatile stratum (No. 3) occurs lower down, may be taken as an indication that both Nos. 2 and 4 fall within the modern period of delta formation. Yet it is not to be supposed that during the period of depression some definite channels, such as that indicated by strata Nos. 2 and 7, did not exist here as well as in the region above, at Port Hudson (Smithsonian Contr. No. 248, p. 5), and elsewhere. But in a 'drowned' delta in course of depression, such channels would, on the whole, be smaller, shallower, and more shifting than during the period of elevation, or the quiescent one that now prevails."

"On the other hand, stratum No. 8 might be regarded as the denuded remnant of a much thicker stratum deposited during the period of depression, and therefore sensibly contemporaneous with the 'Port Hudson clay.' If, as seems probable, it extends to seaward beneath the water of Lake Borgne, it is difficult to conceive it otherwise than as the continuation of the 'blue-clay bottom' of Mississippi Sound, about whose antiquity, and connection with the Port Hudson beds proper, there can scarcely be a question. But until actual examination shall have determined these points, and especially the microscopic similarity of the 'blue-clay bottom' to stratum 8, speculation as to how the latter came to occupy its present position can hardly lead to any useful conclusions."

"It was not, of course, to be expected that borings reaching only to a depth not greater than that sometimes attained by the Mississippi River itself, should throw any direct light on the question of the depth of the delta deposits in the upper delta plain. Yet, in so far as the results of the present investigation corroborate the steady and rapid increase of the marine character as we descend, as well as an appreciable difference of the fauna from that now ordinarily thrown ashore on the delta beaches, they tend to corroborate also my previous conclusion that the delta deposits proper, at least at and above New Orleans, have a comparatively inconsiderable thickness; and that this anomalous structure of the delta of the great river is in direct causal connection with the equally anomalous phenomenon of the mud-lumps."

The memoir contains, besides a map and sections, three plates of fossils; two by Dr. Hopkins, representing the microscopic organisms obtained from the various beds, the upper as well as the lower, and one of larger fossils by Hilgard. Among the latter Prof. Hilgard names, as probably new species, *Serpula fenestrata*, *Turbonilla undecim-sulcata*, *Dentalium læve*, *D. sexangulare*, *Cardium æquilaterale*, and *C. inæquilaterale.*

2. *The Question of the Gonidia of Lichens.*—The discussion opened by the well-known Alternative of De Bary (Morph. and Phys. d. Pilze, etc., p. 291), to which Schwendener gave such prominence, and which Bornet has especially illustrated, has been brought at length to what looks like a conclusion by the observations of Dr. Arthur Minks, of Stettin.

The early *dictum* of Fries, that, however related the Lichens may be to the Algæ by their vegetation, they are Fungi as regards their fruit, was brought to mind again, more than fifty years later, by the just cited pregnant remarks of Professor De Bary, on the relation of the Nostochaceæ and Chroococcaceæ to the Lichens, which he winds up with the (freely rendered) following observation. It is scarcely then, he says, to be doubted that a large part of these families of Algæ stand in near genetic relation to the Jelly-lichens, Ephebe, etc. In what relation, it remains to ascertain. Briefly to indicate my opinion, two suppositions appear to present themselves: Either the Lichens we have spoken of are the perfectly developed fructifying states of plants, the imperfectly developed conditions of which ranked heretofore as Nostochaceæ and Chroococcaceæ, among the Algæ—or the groups last named are typical Algæ, which assume the form of Collema, Ephebe, etc., in consequence of being penetrated by certain parasitical Ascomycetes, which spread their mycelial cells through, and thus condition the growing thallus. (De Bary, as above.) Now there appears to be no doubt that these green cells of Lichens (gonidia) are in exactly the indicated relation to the similar cells of the Algæ named, or that the Lichen fruit is equally in accord with certain Fungus fruits—whatever explanation of either fact be attempted. And Professor Schwendener first took up the consideration of the question from this definite ground: If, said he, at the end of the last of his papers on the anatomy of the thallus, in Naegeli's Beiträge, 1868, p. 195, the possibility of such a process as is indicated in the second supposition of De Bary, and in certain cases even the probability of it, can no longer be impugned, the inquiry forces itself upon us whether it be not possible that all Lichens arise in this way; whether the gonidia be not always to be reckoned typical Algæ, and the colorless thread-cells, in like manner, Fungus-hyphæ. And, after following the consideration of this through several pages he concludes with the remark that, whatever weight be conceded to what he has advanced, it is impossible to deny that the acceptance by way of hypothesis of such parasitic action is authorized by what we know, and that the question deserves, therefore, a thorough investigation. This, Schwendener himself took up the next year (Die Algen-typen der Flechten-Gonidien, 1869), and has also published, besides shorter papers which I am not now able to refer to their places of publication, Erörterungen der Gonidien-frage, 1872, since which he has not returned to the inquiry in print. It has been continued, however, with great interest by others, and if lichenologists have generally looked askance at it, physiologists have done their best, we may say, to show it favor.

Known already among lichenologists by studies of the most sincere and thorough kind—of which I will refer only to his Beiträge z. Kenntniss des Baues u. Lebens der Flechten, pp. 126, and two plates, 1876—Dr. Minks has specially directed his more recent efforts to the resolution of the problem of Schwendener. It had sometimes seemed as if the general, more or less harsh and subjective criticism which makes so large a part of even scientific controversy had been all on one side in this debate, and the pure struggle for objective truth almost altogether on the other; and the interest of unprejudiced observers could hardly fail to attach itself to the last, whether ridiculously aspersed as "notorious" or not. It was yet evident in the *Culturversuchen*, as well of Tulasne as of the later experimenters, especially Reess and Stahl, that elements of uncertainty not conceivably to be eliminated, infected these experiments, and it began to be doubtful whether final results could be looked for by this or, indeed, any other tried way of approach: or, whether the systematic exhibition of Schwendener's hypothesis by Sachs (Lehrbuch, edit. 3, 1873, p. 267) could well expect any satisfactory proof.

Most interesting was it therefore to every student of the Lichens that the keen observer to whom we have referred should buckle to the contest in the most weighty dispute that ever arose in this humble realm of vegetable nature. The long-promised second part of Dr. Minks's Beiträge, with full illustrative plates, has not yet however made its appearance here, and we have only an abstract of the treatise, given by the author in the Regensburg Flora, 1878, to refer to. This is, however, sufficient to indicate the importance of the author's results. It is with the microscopic history of those very minute, often green cells, which have received the name of microgonidia, that this paper is mainly occupied. The cells in question owe their name, as also a recognition of their importance in the question, to Kœrber (Zur Abwehr der Schwendener-Bornetschen Flechtentheorie, 1874), but the whole remarkable exhibition of their real character and history, to the sufficient microscope, and the patient skill of Dr. Minks; who has thus shown that the lichenologists are quite right, and that the gonidium is plainly a modification of the one (ideal) lichen-cell, in the distinction of which from the fungus-cell it may still be taken for a criterium. The first beginning of the microgonidium, as observed in the hyphæ, is a pale-greenish, broken axial column, passing into irregular strings of rounded masses of protoplasm, which finally acquire the cell-wall and whole structure of gonidia, and escaping from the mother-cell are found free, in every degree of intermediate form between microgonidium and gonidium. No distinction between these two appears, except in size or color; and they characterize in their earliest conditions, we have finally to say, every modification whatever of the lichen-cell, which thus bears witness everywhere (to the sufficiently armed and instructed eye) to its natural autonomy.

Owing in part to the peculiar texture of the lichen he had in hand, Dr. Minks, whose observations were made with a power of about 1250 diameters, laid much stress on the preparation of his material with liquor potassæ and sulphuric acid; but Dr. Müller of Geneva, who has repeated the observations of Minks, and with more powerful objectives (Flora, 1878, n. 31) finds that such chemical preparation is by no means always necessary; to which I can myself testify. Microgonidia were seen by Müller in every part of the lichen structure; namely, in the fibrils of the under side, in the cortical cells, in the medullary cells, in the paraphyses, the young thekes, the spores, the basidia, and the spermatia.

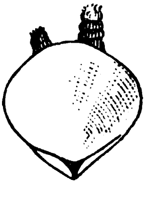
After many unsatisfactory attempts, with dry objectives, and inferior powers, but with some attention to chemical preparation of the material, I have had at last the pleasure, with an immersion $\frac{1}{8}$ of Tolles, to clearly discern the pale-greenish, broken column, passing into rounded, microgonidium-like masses, contained in, and seen at length to escape from, the medullary hyphæ of the Parmelia of Wright Lich. Cub. n. 74 (there called by me *P. tiliacea*, v. *flavicans*, and supposed the same with the *P. relicina*, at least of Montagne) reaching this result with a power of only some six hundred diameters, and without other preparation than a thorough maceration of the tissue in water. With a $\frac{1}{10}$ of Tolles, a 1-inch eye-piece, and power of about 1,000, the whole structure and especially the color was better exhibited; as it was, I need not say, best of all in Tolles's admirable $\frac{1}{16}$ and $\frac{1}{25}$. These observations have all been repeated by my friend Mr. Stodder, with similar results, and I owe entirely to him the manipulation of the two objectives of highest power.

I have only then most heartily to commend to botanists interested, the forthcoming treatise of Dr. Minks, which may soon be expected to appear. E. TUCKERMAN.

3. *Etudes Phycologiques*, by M. GUSTAVE THURET and Dr. EDOUARD BORNET. Fol. Paris, 1878.—This magnificent work surpasses anything which has ever been published relating to

algæ. It comprises fifty-one folio engravings by Picart from drawings of Bornet and Riocreux. Most of the plates were prepared under Thuret's direction between the years 1846 and 1856, and several appeared in a reduced form in the Annales des Sciences of 1851 as illustrations of his article "Recherches sur les Zoöspores des Algues." It was Thuret's intention to publish an atlas of fifty plates, but, at the time of his premature death, ten of the plates had not been engraved. These were finished under the direction of his friend and co-worker, Dr. Bornet. Never before have the algæ been so exquisitely delineated, whether microscopically or in gross. The life-size figure of *Fucus platycarpus* is perfection itself. The text is principally by Dr. Bornet, who has inserted when possible the notes and descriptions of Thuret himself. No apology, however, was necessary on the part of the former; for not only was he the constant companion of Thuret, but his style of writing very closely resembles that of his lamented associate. The text modestly purports to be simply a description of the plates. It is, however, much more: it is a very elaborate exposition of the structure and reproduction of the different groups of algæ. The principal part of the observations on the *Fucaceœ* have already appeared in the Annales. The part relating to the *Phœosporeœ* is very clearly presented, and is the most complete account of the order yet published. The fertilization of *Polyides rotundus* resembles that of *Dudresnaya* in the growth of a number of filaments from the base of the trichogyne. The account of the reproduction in the *Corallineœ* throws a new light on the structure of that order; and for the first time a detailed account is given of the antheridia and cystocorpic spores. W. G. F.

4. *Note on the extension of the coiled arms in Rhynchonella;* by EDWARD S. MORSE.—Years ago VonBuch recorded that Otto Frederic Müller had observed *Rhynchonella psittacea* protrude its arms beyond the anterior borders of the shell. This single observation was not widely accepted, and many doubted the possibility of the arms being exserted in this manner. In the year 1872, while studying living Rhynchonella in the St. Lawrence, I observed a specimen protrude its arms to a distance of four centimeters beyond the anterior borders of the shell, a distance nearly equaling twice the length of the shell. This year I again had an opportunity of studying Rhynchonella in Hakodate, Yesso, and again observed the same features. Specimens lying on the bottom of a glass dish protruded their arms a short distance and remained in this position for hours. A figure is here given representing the appearance of one of them. The movements of the arms were very sluggish though the cirri were constantly in motion. Sometimes the shells closed upon the arms before they were retracted. Lingula has the power of partially protruding its arms, as I have repeatedly observed in North Carolina and Japanese species. Terebratulina can also partially protrude the cirri.



Tokio, Japan, November 26, 1878.

5. *Fauna Littoralis Norvegiæ;* edited by J. KOREN and Dr. D. C. DANIELSSEN. Part III, with 16 plates. Bergen, 1877.—This volume, which, as stated by the editors, has been delayed several years, contains much that is of importance in connection with our own marine fauna, for many of the species, very fully described and figured in it, inhabit, also, the coasts of New England, although in many instances their identity has not yet been pointed out. The text is printed in both Danish and English, in parallel columns. The subjects treated are as follows: New and little known Cœlenterates, by M. Sars; New Echinoderms, by M. Sars; Descriptions of some new Norwegian Cœlenterates, by Koren and Danielssen; Contributions to the natural history of the Pennatulidæ living on the Norwegian Coast; Descriptions of new Bryozoa; Contributions to the natural history of the Norwegian Gephyreæ; a New species of the genus *Pennella* (*P. balænopteræ*). The last four articles are by Koren and Danielssen. Among the Cœlenterata described, are species of *Corymorpha*, *Myriothela*, *Physophora*, *Phellia*, *Zoanthus* and *Alcyonium*. A list of all the Norwegian Pennatulidæ is given, with descriptions of three new genera and six new species of that group. Of the Norwegian Pennatulidæ at least three species inhabit our coast, viz: *Ptilella grandis*=*Pennatula borealis* Sars; *Pennatula aculeata*; *Pavonaria* (=*Balticina*) *Finmarchica*. The *Alcyonium fruticosum* Sars appears to be identical with our common *A. carneum* Agassiz, of earlier date. The *Corymorpha glacialis* Sars is apparently the same as *C. pendula* Agassiz, of later date. Two very different forms, figured as *Myriothela phrygia*, are supposed to represent different stages of growth. The form with gonophores borne on simple elongated, lateral blastostyles is allied to that recently described by me, in this Journal, as *Blastothela rosea*, and may prove to be generically identical with it. The other form has gonophores borne in groups directly upon the hydroid-body. I have dredged a similar form in Eastport harbor. Whether either of these forms, is the original *Lucernaria phrygia* of Fabricius,* is perhaps doubtful. The *Zoanthus Norvegicus* D. and Kor. is probably the same as my *Epizoanthus Americanus*

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* We have, on our coast, another form, which agrees better than either of those here referred to, with the Fabrician description. A specimen dredged off Halifax, N. S, in 52 fathoms, 1877, is about three inches (75^{mm}) high, as preserved in alcohol. The tentaculiferous portion is long and slender, densely covered with slender, rather elongated, capitate tentacles. The gonophores are globular, large, (when mature 2^{mm} in diameter) and are borne in clusters of three to ten, on the sides of lateral blastostyles, of different lengths, each of which bears, at its tapering end, a small group of capitate tentacles, unequal in size. These blastostyles, with their clusters of gonophores, cover less than the lower third of the body. The gonophores near the bases of the blastostyles are much smaller, there being usually only two or three large ones. The mature gonophores contain embryos, covered with tentacles, like those described by Sars. (The embryos of *Blastothela rosea* V. are of the same kind, but smaller). The base gives rise to a numerous cluster of short, slender processes, enlarged at the ends, with adhesive disks for attachment. I believe that this is the genuine *phrygia* of Fabricius, and that the forms described by Sars (originally as *M. arctica*) will prove to be distinct, if the figures be correct.

(1864). Of the Echinoderms, *Oligotrochus vitreus* Sars has been recorded by me, in this Journal, as from deep water, off our coast, and I have also dredged it off Nova Scotia (1877).

The genus ***Kinetoskias*** is established for two very remarkable forms of Polyzoa, both of which have been dredged by us, off the New England coast. One of these (*K. Smittii*) is identical with ***Bugula flexilis***, described and figured by me in this Journal, (vol. ix, p. 415, pl. vii, f. 1, 2, 1875) and probably, also, with the *Naresia cyathus*, figured and partially described by Thompson in the Voyage of the Challenger (vol. i, p. 142). The specimens hitherto noticed have all been attached to the summit of a slender transparent stem, which is regarded both by Thompson and by Koren and Danielssen, as a part of the Polyzoan itself. The numerous specimens dredged by me are, also, for the most part, attached to a stem of the same sort, but varying much in size and condition. They occur chiefly on muddy bottoms, in 50 to 430 fathoms, in many localities, *associated with Corymorpha pendula*, and their "stems" appear to be identical with the dead stems of *Corymorpha*, and like the latter, often have many anchoring rootlets arising from the swollen base. In one instance a small *Sertularia* had attached itself to the same sort of a stem, and the Polyozoan had afterwards attached itself to, and invested, both the *Sertularia* and the supposed *Corymorpha*-stem! Therefore I am led to conclude that the "stem" does not form an integral part of the Polyzoan. Nevertheless its structure is, in other respects, so peculiar as to justify its separation from *Bugula*, as a distinct genus. The second species (*K. arborescens* = *Bugula umbella* Smitt) was dredged by us in 1877, off Halifax, N. S., in 110 fathoms, sandy mud. The article on Gephyreæ is a useful monograph of the Norwegian species, several of which are also found on the New England coast. A. E. VERRILL.

III. ASTRONOMY.

1. *Observatory on Mt. Etna.* Letter to the Editors from Professor S. P. LANGLEY, dated Casa del Bosco, Mt. Etna, January 14, 1879.—You may be interested to learn that the proposed Etnean observatory will probably be commenced in the present year on the site of the "Casa Inglese," a hut used by summer visitors to the volcano, and standing at the foot of the cone, at an elevation of over 9,600 feet. The walls and piers will be constructed chiefly of lava and the building is intended to include the "Casa Inglese," and in addition three other rooms, one of which, containing the equatorial, is to have a conical rotary roof of iron; the others are to be used as a kitchen and bedroom. The equatorial is to be of thirty-five centimeters aperture. It will be seen that the new physical observatory is to be well provided instrumentally. It will be under the eminently competent charge of Professor Tacchini of Palermo; and it will have a situation unequalled by any site at present so occupied in the world.

Science is indebted for this prospective benefit, to Professor Tacchini himself, who has long urged upon his Government the paramount importance of an elevated station for the study of solar physics, and has, it may be observed, cited the brilliant results obtained by our own Professor Young at Sherman as his most convincing proof of the advantage of mountain stations. I write in the hope that the example thus set by Italy may find imitators with us. I have been now for some time at a less high but still an elevated station here (Casa del Bosco is a hut ordinarily unoccupied, about 4,500 feet above the sea), engaged in observations, which it may be hoped will be of some use in determining what may be expected in similar sites in our own territory, their aim being to substitute some sort of quantitative data, for our present conjectural knowledge, as to the degree in which the conditions of vision are improved at higher stations, and to form with something of definiteness a standard of comparison. The results (which will probably appear in a report presented to the U. S. Coast Survey) are not as yet complete; but I may say, in general terms, that while as regards observations of precision (perhaps even as regards work on double stars, and like measures), the gain is less than might have been expected, too much can hardly be said of the immense advantage of an elevated station for almost every kind of research connected with solar physics. This is specially the case as regards the chromosphere; while, as to the corona, concededly, our only hope (with our present means) of materially extending our knowledge of it, lies in the prospect that we may yet be able to see it without an eclipse, if the observer be in an exceptionally transparent atmosphere. I will add that, after a recent expedition to Colorado, and with the conditions of observation there and here freshly in mind, I have no hesitation in saying that our own country has sites at the least equal to the proposed Etnean station in every astronomical requisite, and far easier of access. It is most earnestly to be hoped that something will be done with us in this direction *soon*, even if on a very moderate scale. If we wait for such a distant event as the completion of the Lick Observatory, we shall find the laurels gathered by European observers before we are upon the field.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Earthquake of November* 18, 1878.—In regard to this earthquake (already noticed, vol. xvii, p. 158, Feb., 1879), a special Bulletin from Prof. Nipher, Director of the Missouri Weather Service, dated January 1, 1879, gives the following particulars:

"The shock was felt over an area of fully 150,000 square miles. The region disturbed forms an ellipse, the major axis of which extends from Leavenworth, Ks., to Tuscaloosa, Ala., a distance of over 600 miles. The minor axis extends from near Clarksville, Ark., to a point midway between Cairo, Ill., and St. Louis, a distance of 300 miles. The southern boundary of this region has not been determined with as great accuracy as is desired. The region of greatest disturbance was along the Mississippi, from Cairo to Memphis. Here the shocks were universally felt. The walls of buildings could be seen to move, and strong frame buildings creaked, as when every joint is strained by a heavy wind. At Ironton, the shock was also so severe as to alarm some who lived in brick houses. Along the Missouri, from Glasgow to Lexington, the shock was also severe, awakening many families who thought a wind storm was in progress. It appears that the shock was first felt at Glasgow 11^h 23^m P. M. (St. Louis time). The shock traveled rapidly down the axis of the ellipse, reaching Cairo at 11^h 48^m and Memphis at 11^h 50^m. The velocity of transmission is a matter yet under consideration, and will receive attention in a future bulletin. At Little Rock, Ark., the shock was also felt, although not observed at Clarksville, 35 miles farther up the river."

The bulletin is accompanied by a map of the district, on which and within the ellipse referred to above, there are marked twenty-three stations where the shock was felt and eleven Missouri stations where it was not felt. From this map the direction appears to have been N.W. to S.E. instead of N. to S. as stated in our previous notice. C. G. R.

A second Bulletin in regard to this earthquake has been issued by Prof. Nipher. In it he says:—

"According to the few determinations of time made, there were two distinct centers of disturbance, the shock beginning at the one, near Glasgow, Missouri, at 11^h 23^m P. M.; at the other near Paducah, Kentucky, at 11^h 34^m P. M. (St. Louis time).

The following times are deemed reliable:

Glasgow Region.		Intermediate.		Paducah Region.	
Glasgow	11^h23^m	St. Louis	11^h57^m	Paducah, Ky.	11^h34^m
Leavenworth	11–34	Ironton	11–45 to 11–50	Charleston, Mo.	11–45
Lexington	11–38			Cairo, Ill.	11–48
Macon	11–38			Memphis, Tenn.	11–49
		Lebanon	12–19		
		Little Rock	12–13		

With so few data, it is only possible to give approximate determinations of velocity, as the wave fronts can not be determined with precision. The average velocity was probably less than 200 miles per hour. In some regions the velocity was as low as 160 miles per hour.

Direction of vibrations: Paducah, N.W.–S.E. (Chandelier), Cairo, W.N.W.–E.S.E., Charleston, N.–S., Little Rock, E.–W., Glasgow, N.–S., by some, N.W.–S.E. by others. At Ironton the rumbling sound accompanying the shock, seemed to go *from S. to N.* A similar sound was heard at Gayoso, Missouri, and Memphis, Tennessee. The shock seems to have been more violent in the New Madrid region as far south as Memphis, than in the Glasgow region."

The Bulletin is accompanied by a map, showing the regions affected as above, and also the neighboring field of the earthquake of Nov. 15, 1877. C. G. R.

2. *Forschungen auf dem Gebiete der Agrikulturphysik.* Herausgegeben von Dr. E. Wollny, Professor der Landwirthschaft in München. Band i, 482 pp., and Band ii, 1 and 2 Hefte. Heidelberg: C. Winter.—This excellent journal of agricultural physics, which has entered on its second year, fills a very necessary place in scientific literature. Some of the more important questions in agriculture are largely or purely physical, and demand special study as such. Their investigation will be greatly stimulated and promoted by the existence of an organ in which the hitherto scattered results of research are brought together. The seven numbers of this journal before us contain not only valuable original papers on various subjects belonging to the physics of the soil, the plant and the atmosphere, but in the careful discussions of older investigations, give instructive reviews of nearly all that has been done in several branches of these subjects. The contributions of the editor, Dr. Wollny, on the influence of the color, exposure and texture of the soil, on its temperature, are models of experimental investigation. The original articles are supplemented by abstracts of papers elsewhere printed, and by lists of publications. S. W. J.

3. *The American Journal of Otology:* a quarterly Journal of Physiological Acoustics and Aural Surgery; edited by Clarence J. Blake, M.D., in conjunction with Prof. A. M. Mayer, Dr. Albert H. Buck, Dr. Samuel Sexton, Dr. C. H. Burnett, Dr. J. Orne Green and Dr. H. N. Spencer. Vol. i, No. 1, January, 1879. New York (William Wood & Co.).—This new journal proposes to fill a new and highly important place among American scientific periodicals. The first number contains among others an article on the graphic and photographic illustration of Sound-waves, by Dr. C. J. Blake.

The following books have been received but cannot be noticed in this number:

Wanderings in South America, the North-west of the United States and the Antilles in the years 1812, 1816, 1820 and 1824, by Charles Waterton; new edition, edited by the Rev. J. G. Wood. 520 pp. 8vo. London, 1879 (Macmillan & Co.)

Journal of a Tour in Morocco and the Great Atlas, by Joseph Dalton Hooker and John Ball; with an Appendix by George Maw. 499 pp. 8vo. London, 1878 (Macmillan & Co.)

The Study of Rocks: an elementary Text-book of Petrology, by Frank Rutley, F.G.S. 319 pp. 12mo. London, 1879 (Longmans, Green & Co.)

Ordnance Notes, No. xc. Measurements of Powder Pressures in Cannon by means of the registered compression of oil: experiments by Dr. W. E. Woodbridge, at Washington Arsenal in 1854–55. Washington, Nov. 20, 1878.

Revue de Géologie pour les Années 1876 et 1877; par M. Delesse et M. de Lapperent. Vol. xv, 229 pp. 8vo. Paris, 1879.

Geological Survey of Pennsylvania: Report of Progress in the Juniata District on the Fossil Iron Ore beds of Middle Pennsylvania, by John H. Dewees; with a Report of the Aughwick Valley and East Broad Top District, by C. A. Ashburner. 305 pp. 8vo. Harrisburg, 1878.

Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass. Vol. v, Nos. 8, 9 and 10. Reports on the Dredging Operations of the U. S. Coast Survey steamer "Blake." Description of Sounding-machine, water-bottle and detacher, by Lieut.-Commander C. D. Sigsbee, U. S. N.; pp. 169–179. Echini, by A. Agassiz. Corals and Crinoids, by L. F. de Pourtalès. Ophiurans, by T. Lyman; pp. 181–238. Hydroida, by S. F. Clark; pp. 239–252.

THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXXI.—DR. JACOB BIGELOW.

DR. JACOB BIGELOW died, at his residence in Boston, on the 10th of January last, near the close of the ninety-second year of his age.

While we would pay the tribute due to his memory as by far the most venerable of American botanists, the last survivor of a school in this country which culminated half a century ago, it should also be remembered that he was even at that time distinguished in other scientific avocations, and that from middle to old age he was among the most eminent of physicians. It is not often that we can contemplate a life so long, so richly various, and so well-rounded as his. He was born in Sudbury, Mass., on the 27th of February, 1787; and his father was the minister of the town. That almost goes without saying, most of our distinguished professional men of his and the preceding generations in New England having been the sons of country ministers. He was graduated at Harvard College in the year 1806, Alexander H. Everett and the late Dr. J. G. Cogswell being among the most notable of his class-mates, all of whom he long survived. He directly took up the study of medicine, was licensed as a practitioner in 1809, and after attending one course of lectures in Philadelphia, took his degree of M.D. at Harvard in the year 1810, and established himself in Boston. There he was a practicing physician for about sixty years, and since the death of his senior, Dr. James Jackson, probably the most eminent one. What turned his attention to botany we know not. He early showed an abiding taste for poetry. His commencement part was a poem, and he delivered a *Φ. B. K.*

poem not long after. At about the same time, however, he gave a course of popular botanical lectures in Boston, in connection with Professor Peck, who must have been installed as Natural History professor at Cambridge while Dr. Bigelow was a medical student. The latter possessed the gift of exposition which Dr. Peck lacked; and it naturally came to pass that Dr. Bigelow repeated this course of lectures alone for a year or two afterward.

In the spring of 1814 he brought out the first edition of his *Florula Bostoniensis*, the book which, mainly in its second edition, has been the manual for New England herborization down to a recent day, or rather to a day which seems to us recent. The original volume, of 268 octavo pages, describes the plants which "have been collected during the two last seasons in the vicinity of Boston, within a circuit of from five to ten miles," exceeding those limits only in the case of Magnolia (from Manchester) and one or two more remarkable plants. We know of no other Flora of the kind which was prepared so quickly and so well. The characters are short diagnoses, and in good part compiled. But the descriptive matter must have been original; and it shows that aptitude for seizing the best points of character or most available distinctions, and of indicating them in few and clear words, which has made this manual so deservedly popular. Similar merits distinguish, on its botanical side, Dr. Bigelow's American Medical Botany, a quarto work which was published, in three parts or volumes, between 1817 and 1821, with colored plates—at that time thought to be very good ones indeed—of the principal medicinal plants of the country. He also brought out an American edition of Sir James Edward Smith's Introduction to Botany; and his botanical knowledge, along with that of the materia medica generally and his classical scholarship, placed him at the head, or at the laboring oar, of the committee which in 1820 formed the American Pharmacopœia. The writer used this volume in his medical-student days, and remembers dimly how the account of minor preparations, coming down to jams and conserves, ended with the classical "Jam satis est mihi."

The second edition of the Florula Bostoniensis, published in 1824, while retaining its modest title, was nearly doubled in size and in the number of plants contained, the whole area of New England being included; and it became the Manual of Botany for the region. What a popular and satisfactory work it was, especially to hundreds of amateur botanists, some still living may testify. The third and last edition, issued in 1840, was a reprint, with various additions and corrections, furnished mainly by those who had learned their botany from the preceding one. This is the last Flora or Manual of this and perhaps any other country, arranged upon the Linnæan artificial system. Much later in life the author contemplated a revision of the work, brought up to the time, and illustrated by chromo-lithographic plates, such as we have lately seen turned to good account. But after some consideration the project was abandoned. He did not propose himself to undertake the editorial work: for he had long since passed from actual service into the *emeritus* or honorary rank of botanists; and his active professional life, already verging to its close, was diversified or relieved by other avocations. Indeed some of these were taken up very early. He became Rumford Professor of the Applications at Cambridge in 1816, and delivered annual courses of lectures until 1827, when he published the substance of them in a volume entitled Elements of Technology, here coining this apt word. During all this time, and much longer, he was Professor of Materia Medica in the medical school of Harvard University, namely, from 1815 to 1855; for many of these years one of the physicians of the Massachusetts General Hospital; through all of them, and until old age disabled him, a leading physician of Boston. From the year 1847 to 1863 he was President of the American Academy of Arts and Sciences, of which body he was a member for sixty-seven years!

We cannot here refer to Dr. Bigelow's various professional and literary writings. They are not numerous, but are weighty. His treatise on "Nature in Disease," which contains the famous discourse "On Self-limited Disease," is the most important of them; and an address "On the Limits of Education," delivered in the year 1865 before the Massachusetts Institute of Technology, is notable. It has been said of the latter, that never before was the depreciation of classical study or general culture, as a preparation for technical scientific education, undertaken by so ripe a classical scholar or so wide-cultured a man. His many essays in English and Latin verse, some of which have been privately printed, ought to be collected. Dr. Bigelow lived, honored and trusted, to a good old age before infirmities touched his frame, and only toward the close was the brightness of his acute mind dimmed. The candle at length burnt down, the flame flickered awhile in the socket, and the light went out.

The name will abide in botanical nomenclature. First appeared in Rees' Cyclopedia the *Bigelowia* of Smith, founded on the *Adelia* of Michaux. But that is *Forestiera*. Then Sprengel, in 1821, founded a genus *Bigelovia* on a Brazilian plant which he took to be a Rhamnacea; but it is a species of *Casearia*. Again, in 1824, Sprengel gave the name to a part of *Spermacoce*, the *Borreria* of G. Meyer. Then DeCandolle, in 1824, was proposing a *Bigelowia* on *Solea concolor*, of our own New England, as the Prodromus records, when he found that he had to refer it to *Noisettia*. Lastly, in 1836, DeCandolle bestowed the name of *Bigelowia* upon some golden-flowered Compositæ of the Southern United States, which had borne the name of an Old World genus, *Chrysocoma* (Anglice, Golden-tuft), and he added the complimentary phrase: "A Chrysocoma separatum dicavi cl. J. Bigelow qui floræ Americanæ auream coronam flora Bostoniensi et medica addidit." Although this genus was founded upon only two or three species, it has been vastly extended by the exploration of the western regions of our country, where it forms a conspicuous and characteristic portion of the low shrubby vegetation. More than thirty North American species of *Bigelovia*, besides one of Mexico and two of the Andes of South America, now commemorate our venerable late associate. Most of them were introduced to the genus by the present writer. A. G.

Art. XXXII.—*The Vertebræ of Recent Birds;* by Professor O. C. Marsh.

One of the most marked features in the skeleton of modern birds is the form of their vertebræ. This is so peculiar and so constant that it is considered by many anatomists to be the best distinctive character for the class. In no other group of animals known is there an approach to the saddle-shaped articulation of the centra seen in the vertebræ of birds.

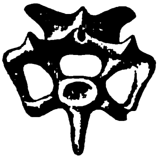
Not only do the presacral vertebræ of all existing birds exhibit this structure, but the many extinct forms now known from the whole series of Tertiary deposits have the same articulation. If we knew only these fossil forms, in addition to the existing species of birds, the origin of this peculiar vertebral articulation would perhaps remain a mystery. Most fortunately, however, a few Cretaceous birds have been discovered which throw much light on this point, and virtually explain the difficulty.

In the toothed birds *Ichthyornis* and *Hesperornis*, we have two widely divergent forms. The latter was a huge swimming bird, without wings, and with vertebræ corresponding fully to the modern ornithic type. *Ichthyornis*, on the other hand, was a small bird, with great powers of flight, and with biconcave vertebræ, as in Fishes and Amphibians, and in a few Reptiles. The marked contrast between the shape of the vertebral articulation in these two genera is seen in the figures below, which show a characteristic cervical vertebra in each form.

In the vertebra of *Ichthyornis* shown in figures 1 and 2, it will be seen that the articulation of the centrum is cup-shaped; while in the corresponding vertebra of *Hesperornis*, the ends of the centrum are saddle-shaped, as in ordinary birds. Thus the distinction between the two types in this part of the skeleton is as wide as between *Ichthyornis* and any living bird.

To the evolutionist, who believes that birds are all closely connected genetically, this difference in structure, at first sight, offers a most serious difficulty; since hitherto we have had no hint of a transformation from the one form to the other, and no explanation of the origin of the modern vertebræ of birds.

1.



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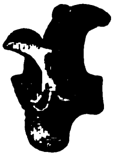

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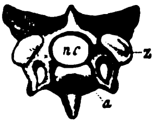
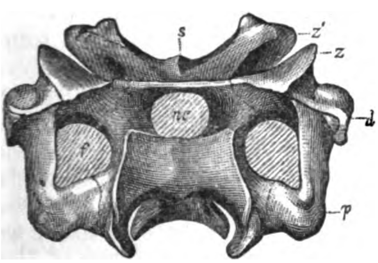


Figure 1.—Twelfth (?) cervical vertebra of *Ichthyornis dispar*, Marsh; front view; twice natural size.
Figure 2.—The same vertebra; seen from the left side.
Figure 3.—Third cervical vertebra of *Ichthyornis victor*, Marsh; front view; twice natural size.

4.



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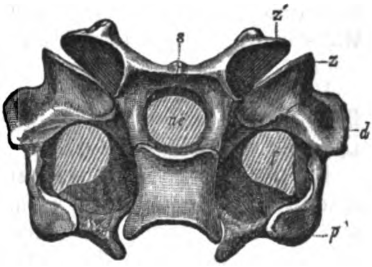

Figure 4.—Thirteenth cervical vertebra of *Hesperornis regalis*, Marsh; front view; natural size.
Figure 5.—The same vertebra; posterior view.
a. anterior articulation; *d.* diapophysis; *p.* parapophysis; *f.* lateral foramen; *nc.* neural canal; *s.* neural spine; *z.* pre-zygapophysis; *z'.* post-zygapophysis.

In the third cervical vertebra of *Ichthyornis*, however, we catch nature in the act, as it were, of forming a new type; by modifying one form of vertebra into another. Following this hint, the connection between these widely divergent types of structure soon becomes apparent; and the development of the modern style of avian vertebra from the fish-like, biconcave form finds a ready solution. In the anterior articulation of this vertebra of *Ichthyornis* (figure 3), the surface looks downward and forward, being inclined at an angle of nearly 60° with the axis of the centrum. In vertical section, it is moderately convex, while transversely it is strongly concave; thus presenting a near approach to the saddle-like articulation. None of the other known vertebræ of *Ichthyornis* possess this character.

This highly specialized feature occurs at the first bend of the neck, and greatly facilitates motion in a vertical plane. If, now, we consider for a moment that the dominant motion in the neck of a modern bird is in a vertical plane, we see at once that anything that tends to facilitate this motion would be an advantage, and that the motion itself would tend directly to produce this modification. With biconcave vertebræ, the flexure in any direction is dependent on the elasticity of the fibrous tissue that connects them, as the edges of the cups do not slide over each other. An increasing movement in the neck of *Ichthyornis* in a vertical plane would tend to deflect the upper and lower margins of the circular cup, and to produce a vertical constriction, and at the same time to leave the lateral margins projecting; and this is precisely what we have in the third vertebra.

This modification of the vertebræ would naturally appear first where the neck had most motion, viz: in the anterior cervicals, and gradually would be extended down the neck; and, on to the sacrum, if the same flexure was continued.

Behind the axis, or where the vertical motion prevails, we find in modern birds no exception to the saddle articulation in the whole cervical series.

In the dorsal vertebræ, this cause would be less efficient, since the ribs and neural spines tend to restrict vertical motion, and hence to arrest this modification. This region, then, as might be expected, offers strong confirmatory evidence of the correctness of the above explanation; for here occur, among modern birds, the only true exceptions known in the presacral series to the characteristic saddle-shaped articulation. In *Strigops* and a few other land birds; in the Penguins, the Terns, and some other aquatic birds, one or more vertebræ in the dorsal region are without the saddle-shaped articulation, and are either opisthocœlian, or imperfectly biconcave. In such instances, we can usually, if not always, detect evidence of an arrest of vertical flexure. This may lock together the posterior dorsals by their neural-spines, as in *Strigops*, leaving the power of lateral flexure; or several vertebræ may be coössified, as in *Accipiter* and some other *Raptores*, in which a stiff back is a positive advantage.

In the coössified sacral series of many birds, one or more of the anterior vertebræ have the saddle-shaped articulation. This, however, is no valid objection to the above explanation, since these vertebræ are really dorsals, and have evidently gradually coalesced with the true sacral vertebræ.

In the caudal vertebræ of recent birds we have, in a measure, the original biconcave structure preserved, for here the motion in every direction was much restricted. The caudal vertebræ of these birds, even in the most aberrant forms, are essentially the same, and in the fossil species the articulations at least appear to follow the general rule. In *Pavo* and *Geoccocyx*, the caudal vertebræ exhibit a tendency to a procœlian union. Some other forms also show unimportant modifications of the normal type of caudal articulation, but nothing to suggest a real objection to the explanation now proposed of the origin of the vertebræ characteristic of Birds.

In bringing together the above facts, and others suggested by them, the classification and development of the various forms of vertebræ appear to be somewhat as follows:

(1.) *Biconcave vertebræ* (Fishes and Amphibians); the primitive type; a weak articulation, admitting free, but limited motion. From this form, have been directly derived the other varieties, namely:

(2.) *Plane vertebræ* (Mammals); affording a stronger joint, with motion still restricted.

(3.) *Cup-and-ball vertebræ* (Reptiles); a strong and flexible joint, well fitted for general motion, and evidently produced by it. The vertebræ are procœlian when lateral motion is dominant (Serpents); opisthocœlian with varied motion (Dinosaur cervicals).

(4.) *Saddle vertebræ* (Birds); the highest type; a very strong and free articulation, especially adapted to motion in a vertical plane, and mainly due originally to its predominance.

This subject will be more fully discussed and illustrated by the writer in a future communication.

Yale College, New Haven, Conn., Feb. 25th, 1879.

ART. XXXIII.—*Notice of Gaston de Saporta's Work: The Plants of the World before the Advent of Man;* by LEO LESQUEREUX.

COUNT SAPORTA's new work entitled "Le Monde des Plantes avant l'apparition de l'Homme," is one of importance, not only for phyto-paleontologists and geologists, but for all who are interested in the history of our planet, in its physical laws, its gradual march of development, and its different phases until it became a fit habitation for the human race.

The first part of the book considers the birth or origin of life and the successive and progressive changes which have modified its forms. The phenomena relating to the existence of living creatures are examined in their applications to organisms from the lowest to the highest in degree of development.

The second chapter reviews the theory of evolution. The author calls it *transformism.* On this subject he rightly remarks, that the theory of evolution does not date from this century; that its origin and history are already old; that the system has been under the critical examination of great minds, who have rightly disparaged some of its extreme tendencies. I quote, in passing, some of the statements of the distinguished author, though they may appear disconnected, in order to show his mode of reasoning on the subject.

"Geology admits great divisions or distinct epochs, and successive formations. But when it comes to the determination of the precise limits of each, to the understanding of the number, the value, or the extent of the stages or subdivisions, the difficulties become inextricable; for generally between two epochs, there appear strata of mixed characters which forcibly excludes all idea of a marked separation between them."

With reference to the remains of plants, he says: "When the details of structure and of geographical distribution, which are recognized in a plant of our time, are in exact analogy with what is known of one or more fossil species of the same genus, it is legitimate to disregard some variations of detail, and to consider the more recent of the two species as a direct continuation of the other. To do otherwise would be to put aside all resources obtained from analogy and induction, or the method itself. Now accepting these premises we may say that there is no tree or shrub in Europe, in North America and in the Canary Islands, which is not found fossil under a specific form more or less intimately allied to one of our time. Nearly always a very ancient type is now represented in its decline, while the more recent appearance of a plant in geological time generally marks its wider extension now."

In the third chapter we have an exposition of the ancient climates, and not merely that exposition which is indicated by paleontology, but an examination of the causes which have produced similarity of temperature over the whole globe during the first geological periods, and of those under the influence of which the zones of temperature became more and more distinct and narrowed. The discussion turns upon the value of the theories offered on the subject; the comparatively great density of the atmosphere overcharged with vapors, thus increasing its capacity for absorbing and preserving heat; the displacement of the axis of the planet; the internal heat of the globe, etc. All these hypothetical causes are recognized by the author as insufficient to account for the phenomenon. He closes the discussion in admitting as more probable the hypothesis of Blandet, supported by d'Archiac, based upon the nebular theory of Laplace, which refers the early temperature to the still excessive heat of the sun derived from the condensing nebula. After speaking of the sun as derived from the condensing nebula, he says: "This hypothesis may be far from giving a solution of all the facts; but it agrees well with the phenomena of the primitive world, and gives us such a clear reason for its climatic laws, the half veiled days of the Coal period with its transparent nights, the tepid temperature of the polar regions, the original extent of the torrid zones and their gradual subsequent contraction to the present limits, that one would be tempted to admit it, though still repeating in a whisper: Could this be the only cause of such a complex concurrence of phenomena?"*

The sentence here quoted closes the first part of the book; which is an introduction, preparing the way for the exposition of the character of what the author calls the vegetable periods of the primitive and secondary epochs.

In treating the subject, Saporta adopts the natural plan of considering the plants, so far as they are known by their remains, in their order of occurrence from the oldest formation to the more recent. The work follows without interruption the march of the vegetation, from its origin, so far as it has been observed, to the end of the Pliocene, and therefore offers multiplied points of comparison for ascertaining the progress of development of the vegetable types, the modification of their characters, the introduction or first appearance of new types, the destruction or disappearance of old ones, etc.

For Primordial, Paleozoic and Mesozoic times, the examination is limited to what is generally known.† The Primordial plants are merely Fucoids. The Silurian are marine species, especially. The author records as terrestrial plants those which have been described from the Cincinnati group. Their nature as representatives of a land vegetation is confirmed by the recent discovery of a splendid fern, *Eopteris Morierei* Sap., near the base of the Middle Silurian of France (the schists of Angiers, zone of the *Calymene Tristani*). This fine fern is placed as the frontispiece of the book—its right place indeed, for the fern, a pinna with large leaflets and perfectly distinct venation, resembles the Neuropterids of the Coal. It plainly proves that the land vegetation of the Middle Silurian, including already plants of so advanced types, must have been varied in its characters. Therefore, according to the law of evolution, it is evidence that a still more ancient land flora existed, probably contemporaneous with the first apparition of the vegetable marine forms.

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*See on this subject an article of J. S. Gardner, in Nature, Dec. 12, 1878.

†Saporta divides the whole fossil vegetable world in four great epochs, the same as those recognized by Geology. 1. Primordial or Protozoic (Laurentian, Cambrian, Silurian); 2. Paleozoic (Devonian, Carboniferous, Permian); 3. Mesozoic (Triassic, Jurassic, Cretaceous), and 4. Neozoic for the Tertiary.

The Devonian is mostly illustrated by species from Canada, some of which are figured, from Dawson, in Dana's Manual of Geology.

The Carboniferous has its illustrations from European plants, common types, also prevalent in the American Coal Measures.

The Permian flora is considered by Saporta as a mere continuation of that of the Carboniferous, the period being one of transition, as he says; though strictly, on the theory of transformism, all the periods are necessary periods of transition. The Permian has few distinct characters in its vegetation, some Conifers only, *Walchia*, *Ulmannia*, *Gingkophyllum*. This last type is already represented in the Permo-carboniferous of North America by *Saportea*, a sub-genus recently established by Fontaine and White, for the description of leaves very similar to those of the present *Gingko* of Japan.

In the Mesozoic (Mesophytic for the plants), the Trias has few typical forms, and these are merely Ferns and Conifers, whose generic relation, for this last group of plants at least, is with the Permian through *Voltzia* and *Albertia*. The Jurassic, *per contra*, whose flora is known to the author by extended researches, is illustrated in the work by numerous wood-cuts representing species published by himself, Heer, Brongniart and others, all from European specimens. The Jurassic floras of Spitzbergen and Siberia by Heer have afforded an important contribution. No species are mentioned from this country, where the Jurassic is not yet satisfactorily known by its plants. In this flora the *Cycadeæ*, *Protophyllum*, *Zamites* and *Protozamites*, are predominant, along with Ferns and Conifers of the Gingko type, *Baiera* and *Salisburia*.

For the Cretaceous the more important documents are taken from North America and Greenland. Europe has few Cretaceous deposits containing plants. In strata of a lower stage, near Beausset, France, remains of a species of fern and of an *Araucaria* have been found, with a fragment of dicotyledonous leaf referred by Saporta to *Magnolia.* The Bohemian Cenomanian has leaves of *Aralia*, *Hymenæa* and *Hedera*, of types recognized, by analogy of characters, in the flora of the Dakota group. From the Senonian of the Hartz are quoted *Abietites*, *Dryophyllum*, *Crednera*, the last two also typically represented in the Dakota group, which, considered by Saporta as referable to the Cenomanian, has five of its species represented as characteristic of the period in the wood-cuts of the work.

In closing the general consideration of the characters of the floras of the three preceding vegetable periods, the author remarks that the second or upper half of the Cretaceous may be viewed as marking by the appearance of dicotyledons the point of departure of the vegetation proper and peculiar to our zone, while the Coal period is that of the whole vegetable kingdom. "From the Cenomanian begins an evolution from which the new tribes progress by multiplication and variation in a constantly increasing proportion."

I shall now consider in more detail some of the points established in the examination of the Tertiary flora, the more important and original part of the book. For I find here a favorable occasion for comparing the essential characters of certain Tertiary groups of this continent, in order to determine thereby some points still in discussion as to their age.

Count Saporta divides the Tertiary into five vegetable periods: Paleocene, Eocene, Oligocene, Miocene and Pliocene. The Paleocene, which corresponds to the Suessonian of Orbigny, is separated from the more recent Cretaceous strata, the Maestricht chalk, by a gap whose width and duration are difficult to ascertain. This period is not yet well known, since the strata containing the vegetable remains of plants have been observed at few localities. To the Paleocene are referred the clay beds of Gelinden in Belgium, the tufaceous deposits of Sezanne in France, and the Suessonian sandstone (*Grès Soissonnais*). The flora of Gelinden is especially composed of species of *Quercineæ*, *Laurineæ*, *Viburnum*, *Hedera* (one species), some *Araliaceæ*, *Menispermeæ*, *Celastrineæ*, *Myrtaceæ*, etc., with some ferns, an *Osmunda* especially. Sezanne has a rich vegetation of large *Juglandeæ*, *Tiliaceæ*, with species of *Magnolia*, *Alnus*, *Salix*, *Virburnum*, *Cornus*, also some *Artocarpeæ*, *Meliaceæ*, *Pterospermeæ*, *Ficus*, *Symplocos* and a *Hedera* (a species of ivy scarcely distinct from the living Irish variety), and a grape. From the upper Paleocene strata have been obtained some *Myricaceæ* and *Araucariæ*, a *Bambusa*, and Palms with flabellate fronds.

In the examination of the remains of plants obtained from the lower Lignitic strata of the Western territories, the essential characters of a number of species have been recognized as intimately related to, even identical with, those of some species of the flora of Sezanne, and from this referred to the Eocene. Count Saporta considers this question, on p. 221 of his book, as follows: "The Lignitic flora of a vast Tertiary formation of North America, rich in combustible mineral, which occupies an immense area in the new Territories in the West, Colorado, Utah, Wyoming, etc., is not yet sufficiently known. From the materials collected under the direction of the Geological Surveys of the United States, the plants appear referable to three different groups of the Tertiary. the lowest evidently corresponding to our Eocene. The relation of this group with the Paleocene of Europe is evident, notwithstanding the great geographical distance of the localities. This relation is manifested by the close affinity of some of the species of ferns with those of Gelinden and Sezanne, by the presence of Palms of similar characters in both countries, with *Artocarpeæ* and *Moreæ* which recall the *Protoficus* and *Artocarpoides* of Sezanne; species of *Cinnamomum* in the Lower Lignitic which have the facies of those of Gelinden. A *Viburnum*, *V. marginatum*, of Black Buttes, is scarcely distinguishable from the recently discovered *V. vitifolium* of Gelinden. It is the same with some other species; and these affinities are so near and so striking, that they force the idea of a connecting link not merely between the floras but between the regions. at the time when they had respectively the vegetation of which we now study the remains."

Considering merely the affinities mentioned above by the celebrated author, it would seem that the Lower Lignitic flora of this continent should be separated from the Eocene, and referred to the new subdivision established by him, the Paleocene. The flora of the Lower Lignitic, however, is distributed through a great thickness of the formations, and shows points of difference which should not be overlooked in comparing typical affinities, especially when the points of comparison are taken from two far distant countries on two different continents; and still more when the comparison relates to single groups of fossil plants, or vegetable remains obtained from a limited area, like that covered by the deposits of tufa at Sezanne. The lowest strata of the Lignitic at Point of Rocks has indeed a *Viburnum* intimately related, as remarked above by the author, to a species of the Paleocene of Gelinden. But it has also an *Ottelia* (tropical type), which is closely allied to another species of this genus, *O. Parisiensis*, of the Eocene of Paris (Trocadero). This local formation corresponds by its fruits, *Nipadites*, to that of the Sheppey beds of the Eocene of England. Along with *Sequoia longifolia*, which, according to Saporta, recalls a

Cretaceous type, the flora of Point of Rocks has also *Sequoia brevifolia* Heer, represented there by the largest proportion of the specimens. The same species is present in the Miocene flora of Greenland (Atanekerdluk) and also in that of the Baltic.* And still, in this small group of plants of Point of Rocks, twenty-seven, reduced to twenty species in eliminating those described from too poor specimens (as *Populus melanaria*), or those without marked geological affinity, we have *Ficus asarifolia* and *Ficus Dalmatica*, as positively identified so far as identity may be ascertained from fossil leaves, with two species of *d'Ettingshausena*. the first from Bilin, the second from Mount Promina, two localities now referred to the Oligocene (*Tongrian*); *Ficus tiliæfolia*, a Miocene type, easily recognized, and found in the flora of the whole thickness of the Western Tertiary strata, even in the Pliocene of California; a *Diospyros;* a fine *Laurus;* a *Sabal* and a *Fucus*, all of recent types. A *Salvinia* also should be mentioned, as all the species of this genus have as yet been referred to the Miocene.

Yet it is not merely from the identification of a few plants that a relation between the floras of two epochs should be fixed or admitted, but from the general characters of the vegetation representing the climate, and from the general facies resulting from the progress of the vegetation, in passing from types admittedly inferior to others of a more advanced degree of perfection becoming more predominant. Considered in this way, the vegetation of the Lignitic, taken as a whole, indicates the action of a climate of an average temperature far above that of the Cretaceous Dakota Group, and still higher than that of the Paleocene, where the Oaks predominate and there are scarcely any Palms. The prodigious abundance of remains of Palms at Golden, at the Raton especially, is exactly comparable to that of the sandstone of La Sarthe (Upper Eocene), which, says Saporta, recall, by the beauty and the large size of their fronds, the Sabals of Cuba and Florida. If we cannot refer the whole Lignitic flora to that upper stage of the Eocene, if we find in it some typical affinities with the Paleocene, this results from the great thickness of the formation, which, in its four thousand feet of strata, may represent groups of floras related to two or more of the geological divisions established from separate groups of plants, like those which in Europe are referred to the Paleocene and the Eocene. This idea seems confirmed when we compare the diverse elements or groups of plants examined until now from the Lignitic. For if the Black Butte and Point of Rocks deposits are allied by the remains of *Viburnum* and *Ficus* of various species, those of Colorado and

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* This Greenland flora, in the opinion of Saporta, Gardner, and other European authors, is closely related to the Eocene flora of Europe.

New Mexico near Trinidad are still more intimately related by a preponderance of Palms, of Ferns of true Eocene character, as recognized by Saporta and Gardner in the identification of Eocene species of England with some of those described from Golden; and also by the presence, at both localities, of *Sequoia* and *Abietites*, of Cretaceous affinity, and of large-leaved *Magnolias* and the *Rhamneæ* closely allied to those of Sezanne.

The Eocene period, as described in Saporta's work, has, at its base, deposits of the coarse limestone of Paris (*Calcaire grossier*) from which have been obtained the large fruits referred to the genus *Nipa* (*Nipadites*), an Indian type intermediate between *Pandaneæ* and the Palms, now inhabiting the flats along the borders of the Ganges. The same fruits, first found at Sheppey, have been discovered also at Paris in the same formation with the species of *Ottelia* mentioned above, along with a few leaves of small Palms, of *Nerium*, *Myrica* and *Zizyphus*.

Saporta has made long and systematic researches on the flora of the gypsum deposits of Aix, which are considered as referable, in their lower part at least, to the Eocene. His celebrated work (Les Etudes), on the vegetation of the Tertiary in the southwest of France, especially considers the fossil remains of that formation. They were discovered, in a very good state of preservation, along the borders of what was once an Eocene lake, whose duration was continued through the Oligocene to the lower Miocene, or Aquitanian. The general characters of this formation are remarkably similar to those of the Green River group of the Western Territories, and in the comparison of the flora also there are indeed some remarkable points of concordance. It is worth while to present in full and for future comparison the description given by Saporta of this group. He says: "This lake or its deposits were for a long time subjected to various changes by natural phenomena. Thermal springs, sometimes sulphurous, sometimes impregnated with carbonate of lime, affording emanations of mephitic gas, then later, volcanic eruptions, followed by flows of basalt, attest the subterranean action which extended even to the water, and brought, at different times, trouble and death to the inhabitants of the lake. Whole shoals of fishes were surprised and buried in the muddy clay of the bottom, a deposit which has faithfully preserved their remains. They are referable to many genera, one of which, *Lebias*, still inhabits fresh water in Sardinia and Northern Africa. Even insects were killed in immense numbers; small and scarcely perceptible flies, mosquitoes, butterflies, libellules, winged ants, bees, gave there to the winds their delicate remains, to be strewn along the shores and buried in the deposit that was soon to be hardened, some of the specimens still preserving traces of their colors. During all this time the flowing water, springs and rivulets, uniting their action to that of the wind and rain, carried to the bottom of the lake fragments of plants of various kinds, especially leaves, branches, flowers and fruits, indeed all the parts naturally torn from the trees and the shrubs growing in the neighborhood along the shore."

For those who have seen specimens of shale of the deposits of Florissant in Colorado, thin laminæ covered with small fragments of plants (their branches, leaves, seeds, flowers, even organs of reproduction, pistils and stamens), along with remains of fishes and insects in immense number, even small feathers, the above description will seem as if dictated by an examination of the deposits of that locality. It applies equally well to those of the Green River station, Elko, the mouth of White River, etc. It is right to remark, however, before looking to the relation in the characters of the plants, that the natural phenomena which have caused the deposits of those remains, have nothing abnormal, are not due to some cataclysm, but are the result of natural atmospheric circumstances. The shales in all the localities named above are in repeated layers of two to five millimeters in thickness, mostly composed of fine sandy materials, the thickest layers of the same nature, but somewhat coarse, all covered upon the upper surface with the various remains mixed together. The thin layers, in repeated superposition, represent therefore annual deposits of materials, mud deposits, laid down in the spring or in the rainy season, hardened in summer, and covered during the process of consolidation by insects, by small floating fragments of plants, etc., mixed with the mud and thrown up by their buoyancy to the surface. The composition indicates a process of consolidation under the influence of heat or summer. Besides the prodigious quantity of insects, the plants, mostly Conifers, are branchlets often deprived of their leaves, like those which, falling to the ground during the winter time, are carried away by water in the spring. A large proportion of the cones are of *Alnus*, and it is well known that these cones are persistent upon the shrubs until the end of the spring. The leaves of some species are extremely numerous, none of them crumpled, folded or rolled, as if driven by currents, but flat, as if they had been imbedded in the muddy surface of the bottom when falling from the trees or shrubs along the border of a lake. In the fish beds of Green River, as they are called, the same phenomenon is observed. One of the richest deposits, eight to ten feet thick, is formed of alternate sandy layers three to five millimeters thick, and it is between the layers that the fishes are found petrified sometimes in prodigious numbers. This evidently shows that under the influence of summer heat, by evaporation and gradual drainage, the area of the lakes or swamps being gradually diminished by shrinkage, the fishes were driven into deeper places, where finally enclosed they perished in masses. Their remains were later covered by the muddy water of the next overflow in the rainy season. In that immense formation of the Green River group, no trace of effects of volcanic agency is seen. It has been through its whole thickness a series of quiet, lacustrine deposits of calcareous clays, during an incalculable period of time. At Green River station, for example, from the bottom of the river to the top of the highest red buttes, about six hundred feet in thickness, the whole series is a succession of those laminated shales, varying only in their constituent beds, there being white calcareous clay, greenish, sandy, red ferruginous clay, in an uninterrupted succession of thin layers.

Considering the data furnished by the plants in reference to the synchronism of the Green River formation, it is only recently, or since the publication of the Tertiary flora, that we have obtained documents numerous and valuable enough for a future comparison. The collections made in the Green River group in 1847 and 1848, by the corps of the United States Geological Survey, and recently by the explorations under the direction of Princeton College, amount for specimens bearing remains of plants to at least ten thousand, mostly from Florissant. These plants have not yet been determined; part of them, those of the United States Survey only, have been superficially examined and separated in groups for definitive study. Of the whole number of plant remains, nearly one-half are leaves of *Planera*, apparently referable to three different species: *P. Ungeri*, *P. longifolia*, both equally predominant, and a less common one, with veins at a very acute angle of divergence and a facies different from that of the others. *P. Ungeri* is extremely abundant in the Miocene of Europe, especially in the upper strata. It is present in the Tertiary flora of *Greenland*, being found there in connection with or upon the same specimens with a *Pterospermites*, a *Hedera*, and *Sequoia Langsdorffi*. It is not quoted from Alaska and Spitzbergen. In the Gypseous beds of Aix one leaf only is mentioned of this species, from the fish beds of Bonnieux. The author says that it is very rare in this formation, but that it becomes more predominant in the flora of Manosque (Miocene). Fragments of Conifers, mostly Miocene types, *Taxodium*, *Glyptostrobus*, *Sequoia*, etc., abound at Florissant, with leaves of *Myrica*, referable to a dozen species at least, two of which are closely related to *M. Zacchariensis* and *M. arguta* of the Gypseous beds of Aix. At the same locality have been obtained numerous specimens of a *Populus*, which, though represented by leaves of various sizes and shapes, are identifiable with P. *Heerii* Sap., of the beds of Aix, where it is very rare. The predominance of *Salvinia*, related to European Miocene types, is also marked in the Green River group, while one species only is described from the beds of Aix, there also very rare. We have also from Florissant a large specimen of a Sabal, which, like *Sabalites major* of the beds of Aix, seems related to the Miocène *Sabal major* of Europe.

If, therefore, we consider the relation of the flora of the Green River group to that of the Gypseous beds of Aix, merely from the number of identical species, it seems to be distant indeed, and more evidently marked with the Miocene. But then, there is against this conclusion the remarkable affinity in the dispersion and fragmentary state of the vegetable remains, and a similar facies of the flora apparent in the predominance of species of *Myrica* and other Southern types, like the leaves described as *Callicoma microphylla*, which, as remarked in the Tertiary Flora, cannot be referred to this Australian genus, but perhaps belong to some peculiar form of *Myrica*. We have also among the vegetable fragments of Florissant, *Diospyros*, *Catalpa*, *Fraxinus*, *Ailanthus*, *Paleocarya Engelhardtia*, *Ulmus*, *Acer*, mostly fruits and flowers, as mentioned by Saporta from the flora of Aix, leaves of peculiar forms of *Quercus*, referable to *Q. salicina* and *Q. antecedens* Sap., and flowers with long stamens, which, lacerated though they are, have some likeness to those of *Bombax*, all from the same flora of Aix.

But it is useless now to look to points of relation. Not only are the specimens from Florissant not yet positively determined, but the locality has, in the whole thickness of its shale, merely vegetable remains of plants growing around a shallow inlet of small area, that of a lake apparently, surrounded for a long period of time by the same kind of shrubs and trees, whose debris, annually strewn and preserved upon the muddy layer of the bottom, does not give a true representation of the general vegetation of the land. The American *Planera aquatica* inhabits only some river swamps of Florida and North Carolina. Its remains, if found in a fossil state, though they might be abundant in a peculiar locality, could not give us the slightest idea as to the facies of the land-flora of these regions. The great difference and variety in the characters of the plants found at other localities of the Green River group, in the deposits of Alkali station, of Elko, the mouth of White River and the cut-off of Green River, show how little we know as yet of the plants of the mighty group, which, like the Gypseous formation of Aix, may represent different geological periods at its lower and its upper parts.

Passing from the lower beds of Aix to the Oligocene (*Tongrian* for its upper part), Saporta sees in its flora the exposition of a more equable and more generally humid climate. The essential types of vegetation recognized in Europe during this period are, for the Conifers, *Libocedrus salicornioides; Chamæcyparis* in two species; some *Sequoiæ*, among them *S. Tourmalii* and *S. Coutsiæ; Taxodium distichum miocenicum*, and *Glyptostrobus Europæus.* With these Conifers the author mentions and figures species of *Comptonia*, some of them of typical affinity to the North American *C. asplenifolia*, others to Austro-Asiatic forms; oaks with coriaceous lobate leaves, a Palm, *Sabal major; Aralia Hercules*, species of *Myrica*, *Celastrus*, *Andromeda*, *Diospyros*, *Myrtus*, *Mimosa*, and, as related to present European types, *Betula*, *Carpinus*, *Ostrya*, *Ulmus*, *Acer*, already mentioned in the examination of the Gypseous formation of Aix. From this it is seen that, as the author remarks, this period is the transmission of an older to a new vegetable period. As to localities whose plants are referable to the Oligocene, the author quotes, for France, the deposits in Auvergne; those of Ronzon, of St. Zacharie and St. Jean de Garguier; the Gypseous beds of Gargas in Provence, of Alais, Armissan and Speeback; then Haering in Tyrol, Sotska in Styria, Sagor in Carinthia, and Mont Promina in Dalmatia. The floras of some of these localities were formerly referred either to the Miocene or to the Upper Eocene. The Flysch and Nummulite beds are Oligocene. From all these deposits eight to nine hundred species have been obtained.

The Miocene period is subdivided into two sections or subperiods. The lowest, the Aquitanian, begins with the regression of the Tongrian Sea, and terminates at the invasion of the Molassic, a period which ends with the more recent strata Miopliocene.

The Aquitanian has beds of lignite sometimes very thick. The more important localities where plants of this formation have been discovered are Manosque in Provence; Cadibona, Piedmont; Thorens, Savoy; Paudeze and Monod in Switzerland; Bovey Tracy in England; Coumi in Eubæa; Rhadoboy in Croatia, etc. The flora of both periods of the Miocene is well known, and has been so admirably well studied and described, especially by Heer, that every phytopaleontologist has become acquainted with its essential types. A large number of them are figured in Saporta's book.

The Oligocene types of Conifers, as also those of the dicotyledons, still remaining in the present flora, pass of course through the Miocene. But the climate of this period has a far less degree of uniformity, or the zones a less degree of expansion, and therefore the floras become more diversified, according to the latitude of the localities in which they are observed. Thus the flora of Coumi is marked by a large profusion of meridional forms, though those of the temperate zone are not all excluded. In this flora appears the last European Cycad. Species of *Sabal* are present in all the groups of plants of the Aquitanian. The vegetation of the molasse is still more widely elucidated in the great tertiary flora of Heer. A number of species of *Populus*, *Planera Ungeri*, *Platanus aceroides*, *Liquidambar Europeum*, *Podogonium* species, *Ficus tiliæfolia*, *Myrica Œningensis*, *Comptonia acutiloba*, oaks belonging to the live oaks with semi-persistent leaves, and related to types of Mexico and Louisiana; species of *Tilia*, *Ulmus*, *Celtis*, *Magnolia*, *Liriodendron*, *Vitis*, are the predominant plants of the Upper Miocene period. They are most of them, if not all, recognized in the present vegetation of North America, to which that of the Miocene of Europe has been often compared.

The more important localities where remains of Upper Miocene plants have been discovered in Europe are Salzhausen, Rockenberg, etc., Weteravia; Gunzburg in Bavaria; Bilin in Bohemia; Manat and Mount Charray in France; Œningen in Switzerland; Parschlug and Gleichenberg in Styria; Tokay in Hungary; Vienna in Austria.

In the comparison of the American groups of Tertiary fossil plants, none has been found to agree with those of this period, by analogy of character, but that of Carbon or of the Washakie group, where essentially *Platanus aceroides* or *P. Guillielmæ*, and *Acer trilobatum*, abound, together with species described by Heer from the molasse of Switzerland. That peculiar *Ficus tiliæfolia*, considered as Miocene in Europe, easily recognized by its inequilateral leaves and the coarse and deep venation, abundant as it is in different localities of the Lower Lignitic, has also left its remains at Washakie. It is universally distributed in the ancient floras of this continent.

Saporta's book opens the examination of the Pliocene flora, by an interesting introduction. "The Miocene marks for Europe an era of vegetable splendor, an epoch of quiet temperature without extremes, of beneficial humidity, favoring the highest development of the vegetation upon a continent not yet feeling the change to which it was about to be subjected. The Pliocene period is the declining age of the European flora, the time when the climatic conditions are definitively altered, when the vegetation becomes gradually poor and ceases to gain anything. The progress of the phenomenon is slow, but it moves along an inclined plane on which it never stops. Those ornamental plants, those precious trees, those noble and elegant shrubs which are now carefully trained by artificial culture in European conservatories, were until then inhabitants, of Europe, but left it forever. One by one the ostracised plants take their departure, lingering here and there on the road to exile. It is this exodus that we should have to describe if we could follow, step by step the march of retrogression, and indicate species by species, the progress and the result of this abandonment of our soil."

The decline in the richness of the vegetation of the Miocene period is described in detail by the author, and its causes are clearly exposed. He considers it (as remarked already) to be essentially the result of a gradual lowering of the temperature, which from its origin at the end of the Eocene, had been in constant progress until now, with casual modifications. It was due to the influence of a phenomenon which has acted upon the whole globe.

The vegetation of the Mio-pliocene has been rarely observed in Europe. From Sengaglia, Italy, Massalongo has described species of the genera *Greuia*, *Acer*, *Fagus*, most of them of present American types. The Conifers are still those of the Molasse, to which *Salisburia adiantoides* is added. *Sassafras*, *Liriodendron*, *Tilia*, *Cercis* are represented there also. Saporta has lately published the flora of the Pliocene tufa of Maximieux, with *Oreodaphne Heerii*, *Laurus Canariensis*, *Persea Caroliniensis*, *Acer opulifolium*, *Nerium oleander*, adding to the specific names the appellation *pliocenica*, all being mere varieties of species living now in the islands or African shores a few degrees south of France, or in the Gulf region of North America. There is also a *Buxus pliocenicus*, a *Torreya*, *Viburnum rugosum*, an *Ilex*, a *Juglans*, and among the ferns, *Woodwardia radicans* and *Adiantum reniforme*. As remarked by Saporta, the Poplar (*Populus alba pliocenica*), the Button Wood, *Platanus*, the Magnolia and the Tulip tree in the Mio-pliocene of Europe were about the same as the species now inhabiting North America; are specifically recognizable, though marked with slight differences. The relation of these species and others named by the author to some of the present time is examined by an exposition of the gradations which have given them their present characters.

The last chapter, entitled "a general insight into the ensemble of the period," cannot be summed up in a few sentences. It relates especially to the phenomena which have contributed, as causative agents or as elements, to the gradual modification of the vegetation from the end of the Mesozoic to the present times. A mass of facts are grouped, compared and discussed, in support of the conclusions, as evidence of the gradual development (evolution) under various local or general influences. As an exemplification of the march of transformism the author figures the leaves of three vegetable types, *Laurus*, *Hedera*, *Nerium*, as they appear in successive periods from the Eocene to the end of the Pliocene.

The remarks on this subject are rendered more interesting and conclusive by their correlative application to the animal kingdom. There is between the modifications of animal and vegetable types a remarkable coincidence which, however, is a matter of course, as animal life depends on the plants. It is well known, for example, that the Giraffe in its African wilderness especially feeds upon Acacia or Gum trees. This kind of plants appears first at the base of the Gypseous beds of Aix, at the end of the Eocene, and there also have been found the bones of Xiphodon, prototype of the Giraffe, which in its present form appears later in the Miocene in its migrating progress from France to Africa. It is at this epoch of the Upper Eocene that mammals make their first appearance in Europe, an advent prepared and predicted by the luxuriance of the vegetation of the Lower Eocene.

It should not be supposed from these cursory remarks, that Saporta's book, "Le Monde des Plantes," is a dry exposition of facts, or, descriptive enumeration of fossil remains, prepared only for the instruction of the paleontologist. Far from this; it is an exposition of the vegetation of our earth, in its gradual modifications from the oldest antiquity to our time, in a series of tableaux as clearly defined by words as they could be by the pencil of a painter. To these tableaux a multiplicity of facts,—some of them new and all instructive—give life and animation; while they are colored by the richness and brilliancy of an admirable style. The book is thus read without fatigue and with increasing interest, from the first page to the last.

Columbus, O., January 23, 1879.

ART. XXXIV.—*Double Stars discovered by Mr. Alvan G. Clark;*
by S. W. BURNHAM.

THE double stars discovered by Mr. Alvan G. Clark, of the well-known firm of Alvan Clark & Sons, telescope makers, Cambridgeport, Mass., are for the most part prominent and interesting objects, and, with the exception of Sirius, have not been published, or brought to the attention of astronomers generally. They are nearly all difficult pairs, and such as require for measurement a first-class, if not a large, instrument. All the recorded measures of each star in the following list are given, except of the first. Most of the micrometrical observations are by the Washington observers, and by Baron Dembowski and myself. All of the latter measures have been made at the Dearborn Observatory, Chicago.

The names and places of the stars are as follows:

No.	Star.	R. A. 1880.	Decl. 1880.	Magnitudes
1	Sirius.	6h 39m 53s	−16° 33′	1 ..10
2	W VII, 1131.	7 40 20	+28 59	8 ..11
3	ρ Hydræ.	8 42 5	+ 6 17	5 ..13
4	L 23271.	12 20 37	+ 0 29	7½..10
5	46 Virginis.	12 54 25	− 2 43	5–6..8–9
6	Arg. (30) 2534.	14 28 45	+30 21	9½..10
7	ε Coronæ.	15 52 37	+27 14	4 ..13
8	102 Herculis.	18 3 38	+20 48	5 ..12–13
9	γ Lyræ.	18 54 27	+32 31	3 ..12
10	P XIX, 257.	19 39 15	+10 29	7½.. 7½
11	ζ Sagittæ.	19 43 39	+18 51	6 .. 6
12	α^2 Capricorni.	20 11 24	−12 55	3 ..
13	τ Cygni.	21 10 0	+37 32	5½.. 8
14	78 Pegasi.	23 37 57	+28 42	5 .. 8

No. 1. *Sirius.*

The history of this interesting system is too well known to require more than a brief mention. From periodical irregularities in the observed proper motion of Sirius, Bessel, more than thirty years ago, suspected the existence of a satellite revolving with the large star around their common center of gravity. The theoretical orbit of the disturbing body was calculated by Peters, and a period of fifty years found to satisfy the meridian observations. The suspected companion was looked for by many observers without success. In January, 1862, Mr. Clark placed the 18½-inch object glass, now at the Dearborn Observatory, Chicago, then the largest object glass in the world, in a temporary stand, and turned it upon Sirius. A small star was at once detected almost exactly in the place assigned by theory. Once discovered, it was readily seen and measured with the same instruments with which it had been vainly looked for before. I have seen it repeatedly with my 6-inch Clark refractor; but a steady air is necessary with any moderate aperture, because of the great brilliancy of Sirius, which overpowers the light of the small star, and because of its low altitude in northern latitudes. Probably in the southern hemisphere a good 5-inch object glass would show it satisfactorily. Why it should have remained so long undiscovered, after attention had been called to it, cannot be easily explained. For this discovery, Mr. Clark was awarded the Lalande gold medal.

The companion has been measured every year since 1862, and during the latter portion of the time the observations are very numerous. The last orbit of the theoretical satellite, computed by Auwers, based upon all the available observations of proper motion, gives a period of 49·40 years. From these elements an ephemeris has been calculated for every second or third year, which is given in the following table, together with some of the actual measures made near the corresponding times. It will be seen that the angular motion of the real star is more rapid than that of the theoretical star, and with a less change in distance, indicating a longer period than fifty years.

Calculated.			Observed.			
1862·0	85°·4	10″·10	1862·2	84°·6	10″·7	Bond.
			62·2	85·0	10·09	Rutherfurd.
			63·2	82·5	10·15	O. Struve.
1865·0	79·9	10·78	1865·2	77·2	10·60	O. Struve.
			65·2	76·8	10·77	Förster.
			65·2	75·0	10·07	Secchi.
1868·0	75·0	11·15	1868·2	70·2	11·25	Vogel.
			68·2	69·5	11·35	Bruhns.
			68·3	71·6	10·95	Engelmann.
			69·2	68·6	11·26	Dunér.
1871·0	70·3	11·20	1871·2	64·0	11·21	Dunér.
			72·2	59·8	11·14	Dunér.
			72·2	67·7	11·55	Newcomb.
1874·0	65·5	10·95	1873·2	65·8	11·12	Hall.
			73·2	60·9	10·65	Dunér.
			73·9	59·4	12·27	Hall.
			74·2	59·0	11·46	Newcomb.
			74·2	58·7	10·99	Holden.
			74·2	57·9	11·10	Hall.
			75·2	57·1	10·81	Dunér.
			75·2	56·6	11·41	Newcomb.
			75·2	56·3	11·08	Hall.
1876·0	62·1	10·59	1876·1	54·9	11·82	Holden.
			76·2	55·2	11·19	Hall.
			77·1	53·1	11·20	Stone.
			77·2	52·8	11·35	Holden.
			77·3	53·4	10·95	Hall.
1878·0	58·4	10·05	78·0	52·4	10·83	Burnham.
			78·1	50·5	11·07	Holden.
			78·2	51·7	10·76	Hall.
			79·1	50·7	10·44	Burnham.
1880·0	54·2	9·33				

The last observed position is the mean result of ten nights' measures made at the Dearborn Observatory in the past two months.

The existence of another satellite has been suggested as an explanation of the variation shown above, but all attempts to find any other body have thus far been unsuccessful.

No. 2.

Discovered in May, 1876, with the 12-inch object glass now at the Vienna Observatory. This very unequal pair is in the neighborhood of Pollux, about 40′ south, and a little following. The only measure is the following:

Burnham.....P=114°·9 D=0″·81 1879·0 1*n*

No. 3. *ρ Hydræ.*

The very minute attendant to this star was detected with the Washington 26-inch refractor. The only measures I am acquainted with are those made with the 18½-inch of the Dearborn Observatory. A mean of three observations is as follows:

Burnham ....P=144°·9 D=12″·40 1878·0 3*n*

No. 4. L 23271.

A close and unequal pair discovered May 19, 1876, with the Vienna 12-inch object glass. The following are all the measures:

Hall	P=233°·6	D=0″·85	1876·4	3*n*
Dembowski ..	234·1	0·87	1877·4	2*n*

No. 5. 46 *Virginis.*

Discovered on the same evening as the preceding, and with the same glass. It is a fine pair, and just within the reach of a 6-inch aperture. It has been measured as follows:

Hall	P=158°·9	D=1″·32	1876·4	3*n*
Dembowski ..	148·5	1·21	1877·4	2*n*
Stone	145·7	1·15	1878·2	1*n*
Burnham	151·5	1·48	1878·3	2*n*

The magnitude of the small star is rated 8 by Dembowski, 9·5 by Stone, and 11 by Hall.

In measuring this pair, a very faint companion, about 13th magnitude, was detected.

P=116°·9 D=33″·86 1878·3

No. 6.

A difficult pair of small stars in a low-power field with *σ* Bootis, *np.* It has been measured by Dembowski only, and the following is a mean of two observations:

Dembowski ...P=139°·8 D=0″·76 1877·0 2*n*

This was also found with the Vienna glass.

No. 7. *ε Coronæ.*

A very difficult and unequal pair discovered May, 1876, with the Washington 26-inch. The companion is an exceedingly minute point of light, even with a large aperture. Mr. Edgecomb, of Hartford, sees it with a 9·4-inch Clark refractor, but this must be regarded as a very remarkable test of acute vision. The following are all the measures:

Hall	P=351°·4	D=2″·17	1876·4	4*n*
Burnham	360·2	1·86	1878·3	2*n*

No. 8. 102 *Herculis.*

A faint companion detected with the 12-inch Clark object glass now in the possession of Dr. Draper. The only measure is:

Burnham.... P=46°·9 D=23″·42 1878·4 1*n*

No. 9. *γ Lyræ.* (*O*Σ 544.)

This pair, discovered a number of years since with the 12-inch glass now at the Vienna Observatory, is one of the recently published additions to the Pulkowa Catalogue. It has been measured as follows:

Otto Struve..	P=296°·9	D=13″·79	1868·6	3*n*
Newcomb....	297·8	12·48	1874·5	1–4*n*
Burnham	301·1	12·76	1878·4	2*n*

No. 10. P XIX, 257. (AC=Σ2570=♅I. 91=S 723.)

This has been known as a wide pair nearly a century. With the Draper 12-inch, the large star in August, 1875, was found to be an excessively close pair. I have measured this with Dearborn Observatory refractor on four nights, as follows:

P=126°·1	....	1877·68
147·4	....	1877·72
147·0	D=0″·26	1878·62
142·0	0·32	1878·70

There is no evidence of change in the 9·5 magnitude star, as will appear from the following observations:

Herschel I...........	P=278°·2	....	1783·6	1*n*
Struve	276·2	D=4″·08	1827·0	3*n*
Mitchel	275·7	3·95	1847·7	1*n*
Secchi	275·3	4·10	1857·6	1*n*
Wilson and Seabroke.	279·9	3·87	1874·1	2*n*
Wilson and Seabroke.	277·8	4·30	1876·7	1*n*
Burnham	276·6	4·16	1878·7	1*n*

No. 11. *ζ Sagittæ.* (AC=Σ2585=♅II. 30=S*h* 307.)

Discovered as a wide pair in 1781 by Herschel I. It was measured by many observers down to 1875, when the duplicity of the principal star was detected with the same instrument with which the two preceding discoveries were made. My measures of this at the Dearborn Observatory indicate an increase in the distance. I found it obviously less difficult in 1878 than the previous year. The individual measures are as follows:

P=158°·3	D=0″·22	1877·72
157·6	0·24	1877·73
158·1	0·27	1877·77
158·7	0·35	1878·64
155·4	0·35	1878·70

Struve gives the magnitutes, 5·7 and 8·7, of the wide pair. These stars appear to be relatively fixed.

Struve	P=312°·8	D=8°·49	1831·1	7*n*
O. Struve	311·2	8·71	1846·9	7*n*
Wrottesley	311·8	8·77	1854·6	3*n*
Wilson and Seabroke.	311·2	8·8	1873·6	1*n*

No. 12. α^2 *Capricorni.* (AB=H 608.)

Herschel II discovered a 16-magnitude companion to this star and entered it in his second catalogue of double stars. Since that time it has received but little attention from double-star observers. Under favorable conditions a 6-inch refractor will show it fairly. The following are all the measures:

Herschel II	P=141°·2	D=6″ ±	1830±	1*n*
Mitchel	144·1	6·36	1846·7	13*n*
Holden	146·2	....	1874·6	2*n*
Burnham	150·2	7·41	1878·5	3*n*

In November, 1862, with the 18½-inch object glass now at the Dearborn Observatory, Mr. Clark found that this minute companion was itself a close, equal pair. Professor Young was able to see it with the 9·4-inch refractor of the Dartmouth College Observatory when observing at Sherman, Colorado, from an altitude of more than 8,000 feet above the sea level. This, to anyone who has seen this minute pair, is a striking illustration of the importance of getting above the lower atmosphere. The following are all the measures:

Holden	P=57°·6	D=1″·72	1874·6	1*n*
Newcomb	58·6	1·24	1874·6	1*n*
Hall	65·2	1·14	1875·7	1*n*
Hall	63·2	....	1876·7	1*n*
Burnham	61·2	1·06	1878·5	2*n*

No. 13. τ *Cygni.*

This fine pair was discovered in October, 1874, with the 26-inch object glass manufactured for Mr. L. J. McCormick of Chicago. It has already shown rapid angular motion, and is undoubtedly a binary system. It has been carefully and regularly observed by Baron Dembowski. The individual measures are as follows:

P=174·8	D=1·06	1874·90
174·3	1·43	1875·33
171·0	1·33	1875·51
171·5	1·37	1875·67
168·9	1·26	1875·89
163·2	1·26	1876·76
159·8	1·23	1876·82
157·0	1·47	1877·39
157·7	1·25	1877·43
157·5	1·33	1877·59
155·8	1·37	1877·70
155·0	1·21	1877·79
152·5	1·15	1877·84
154·2	1·14	1877·92
152·9	1·17	1877·94

Other measures, with the mean results of Dembowski's observations, are:

Newcomb	P=162°·6	D=1″·10	1874·8	2*n*
Dembowski	174·5	1·24	1875·1	3*n*
Dembowski	170·5	1·32	1875·7	2*n*
Dembowski	161·5	1·24	1876·8	2*n*
Waldo	166·9	1·62	1876·9	2*n*
Hall	160·2	1·03	1776·9	2*n*
Dembowski	155·3	1·26	1877·7	8*n*
Burnham	150·0	1·06	1878·4	1*n*

There is a third extremely faint star:

Newcomb	P=261°·7	D=15″·10	1874·7	1*n*
Hall	260·3	15·68	1876·9	1*n*

No. 14. 78 *Pegasi.*

An unequal, but not very difficult pair, discovered in Nov., 1875, with the 12-inch glass now at the Morrison Observatory, Glasgow, Missouri. Dembowski gives its magnitudes: 5·0 yellow, 8·1 olive. The only measures are:

Dembowski	P=192°·0	D=1″·45	1876·6	4*n*
Burnham	190·8	1·54	1878·8	1*n*

Chicago, March 1, 1879.

ART. XXXV.—*Underground Temperatures on the Comstock Lode;* by JOHN A. CHURCH, Professor of Mining, Ohio State University, Columbus, Ohio.

DURING the summer and fall of 1877, I was engaged in making an extended examination of the mines situated on the Comstock lode in Nevada.* Though investigations of the kind described in this paper were but a subordinate part of the proposed work, and the time given to them necessarily restricted, enough facts were accumulated to show on how vast a scale the heat phenomena of the district are exhibited.

The Comstock mines are not only the only hot ones of note in this country but they appear to be the hottest in the world. The highest mine temperature reported to the British Coal Committee was 106° F., but some of the Cornish mines have shown an air temperature of 100° to 118° F. There the air was hotter than the rock, which is never the case on the Comstock. The hottest water reported in a Welsh mine had a temperature of 125° F. (J. A. Phillips). All of these observations are surpassed by the extraordinary conditions of the Comstock.

*** This examination was made in connection with the United States Survey of the Territories west of the 100th meridian, in charge of Lieut. Geo. M. Wheeler, Corps of Engineers, U. S. A.**

The rock in the lower levels (1900–2000 feet) of the Comstock mines appears to have a pretty uniform temperature of 130° F. This was the reading obtained for me on several occasions by Mr. Comstock, foreman of the Ophir mine, and about the same temperature was found by Mr. Perrin, foreman of the Chollar Potosi, by Mr. Cosgrove, foreman of the Yellow Jacket (139½° F. and 136° F., 2200 foot level), and by myself in the Crown Point and other mines. These readings were obtained by placing a thermometer in a drill-hole immediately after the hole was finished, and leaving it there for periods varying from ten minutes to half an hour.

The holes in which the thermometers were placed were not sunk especially for this work of testing, but were the ordinary drill-holes made for the purpose of blasting the rock. They varied therefore from about ten inches to three feet in depth, but their shallowness by no means indicates that the results obtained are vitiated by alteration of the conditions through exposure to radiation.

Mining on the Comstock proceeds with extraordinary rapidity. The drifts are advanced steadily at the rate of three, five, and sometimes even eight and ten feet a day, and therefore the ground in which the miners are working is always fresh ground. The drill-hole which is made to-day was covered a week ago by thirty to fifty feet of rock. Very often the holes were in ground which had been exposed only one or two hours, having been sunk immediately after a blast which threw off four or five feet of the rock. The surface which was thus thrown down itself had not been exposed more than twenty-four hours. The high temperature and small flow of air in the heading forbid the supposition that any sensible diminution of heat could have taken place at the bottom of a drill-hole made in material of such low conductivity as rock. These facts give the results as much value as if they had been obtained from holes twenty feet deep.

The surface of the rock exposed to the air of the drift was found on one occasion to be about 123° F., the experiment being made near the "header" or end of the drift. The air itself was found to show considerable uniformity when its temperature was taken under circumstances that were at all similar. In freshly opened ground it varied from 108° to 116° F., and higher temperatures are reported at various points, reaching in fact as high as 123° F. in the 1900 level of the Gould & Curry.

The temperature of the air is subject to more fluctuations than that of the rock, for the simple reason that it is artificially supplied to the mine, and varies according to the distance to which it is carried, the quantity, velocity in the pipe, its initial temperature, and moisture in the drift. The most important causes of variation are the length of the drift and the presence or absence of water. In general the variation at similar depths is not more than eight degrees. Drifts that do not exceed two or three hundred feet in length are *usually* not above 110° or 112° F. in temperature and often they are below this. But when the length increases to 1200 and 1500 feet the temperature may rise to 116° F. without any other change in the circumstances. But much higher temperatures are encountered in places where the increase cannot be attributed to artificial causes.

These limits are, however, not in the least degree true of the water which enters the drifts from the country rock, and also from the lode rocks. That approaches more nearly 150° F. The vast body of water which has filled the Savage and Hale & Norcross mines for two years, and from which it is safe to say a million tons of water have been pumped within twelve months, gave me a temperature of 154° F. Even after being pumped to the surface through an iron pipe exposed, in the shaft of the Hale & Norcross, to a descending current of fresh air for more than a thousand feet, and then flowing for one or two hundred feet through an open sluice in a drain-tunnel which discharges into a measuring-box, the water in this box was found to have a temperature of no less than 145° F.

But the water varies in temperature in different parts of the lode like the rock and the air. In the East crosscut 2000 foot level, of the Crown Point Mine, which is noted for its extreme heat, a small stream of water, after flowing for nearly one hundred and fifty feet over the bottom of the drift, was found to have a temperature of 157° F. Here the drift was closed so that the water was but little exposed to evaporation. On the contrary, in other places the water is much less hot, but I believe it is always hotter than the air, and in many cases it appears to be hotter than the rock is found to be, except in especially hot spots.

These places of exceptionally high temperature are very numerous throughout the lode and they appear to occupy narrow belts. The East crosscut of the Crown Point 2000 feet level, which was temporarily abandoned and boarded up on account of the heat, gave me an *air* temperature of 150° F., the thermometer being thrust through a crack in the boarding. I felt convinced that at the head of this crosscut the heat must be higher than this, and Mr. Balch, foreman of the mine, informed me that it had been proved so. Another hot spot is in the Imperial Consolidated Mine. Here the Black Dike splits, sending a shoot off to the northeast, and a drift has been run on the two thousand foot level, along the eastern side of this branch dyke. This proved to be a very hot spot indeed. Rock, air and water were all so much above the usual limits of temperature even in these hot mines that the work of cutting the drift must have been extremely severe. It might not have been accomplished had not the expedient been adopted of boarding or "lagging" up the sides of the drift with a double thickness of plank, breaking joints. This confined the water, which poured down the walls, to a tight chamber, and left the main part of the drift for the men to work in comparative comfort. The lagging remains, and has been carried around into the main drift, which is still in active use. Its joints are calked with tow, and, one of these being stripped for me, the steam from the water immediately poured out and proved to be scalding-hot when tested by the finger. I did not, however, succeed in getting a fair reading of the thermometer, because the crack was too small to admit more than the end of the bulb. The thermometer must have cooled by the evaporation of condensed moisture from its bulb; but, even under these adverse circumstances, the temperature of the steam was taken at 123°.

The Belcher south incline has a hot belt of rock, quite narrow, a short distance above the 1900 station, and in fact similar hot places are found in most of the mines.

It is noticeable that the neighborhood of a dike is apt to be hotter than other portions of the rock. This is the case in the Julia, and in the Imperial, the branch dike is hot, as just mentioned, and the main incline, which is quite near the Black Dike has always been noted for its extreme heat. But nearness to the Black Dike is also a characteristic of most inclined shafts on the lode. Some are west of it; some in it for long distances; others east of it. These inclines do not all exhibit unusual heat and it will be shown farther on that there is a special cause for the exceptions.

Belts of excessively hot ground are not the only noticeable phenomena in these mines. More remarkable still are the belts of unusually *cold* rock. These are fewer in number than the hot belts, but they are also strongly marked. They are always wet, and the water that drips through the crevices of the shattered rock that composes them is noticeably cold to the touch, and cools down the air of the drift. Such a wet, cold belt of rock exists on the eight hundred foot level of the Justice Mine, and there is a very decided change of temperature in passing from one side of it to the other. Lest the low temperature of this spot should be attributed to the water which drains through it from the surface, it is well to add that water drips from the rock in numerous places in these as in most mines, and that usually it is hot, or at least warm.

Other cold belts are found in the mines which are not so cool as that in the Justice, but are perceptibly cooler than the rock at a short distance from them. They complete a welllinked chain of heat phenomena, extending from rocks that are sensibly cold to the touch, and may not have a temperature above 50° or 60° F., through rocks that have the average atmospheric temperature, and those which are as hot as surface rocks ever become in Nevada, to those which have a temperature of 157° F. There is no reason to doubt that the gradation is quite regular, and the transition from the lower to the higher temperature is made through a much larger series of intermediate steps than the accidental thermometer readings taken show.

The rock is usually dry. Wet portions exist, but these are disposed in comparatively narrow bands parallel with the lode and separated by thick masses of rock; the lode is usually perfectly dry, and never exhibits more than the average leakage of mines. Wet rock is the exception, and dry rock the rule, through the whole lode. In the drifts cut through this hot, dry rock, the walls of the freshly exposed surfaces are painful to the hand, and the air is often filled with dust. The rock is both hard and tough, but, in spite of its strength, it gives an impression of fine porosity to the touch, due probably to its trachytic character. It often has the odor of clay, but not always. It may be slightly adherent, or the impression of dryness upon the tongue may be due to its heat.

The plan of the Yellow Jacket mine is simple and such as to eliminate complications from the single problem of heat absorption by moving currents of air from rock surfaces. From the 1,531 level two parallel winzes are sunk on the lode, inclining with it. They are four hundred and thirteen feet apart, and connected on every lower level by the main north and south drift. The Yellow Jacket is a downcast mine, and the air current passes down the vertical shaft to the 1,119-foot level, thence down the incline to the 1,531 level, through a drift to the south winze, and thence down this winze to the 2,200 level, the bottom of the mine. On its way from the 1,531 it sends a current through the 1,732, 1,935 and 2,040 levels, these currents being reunited in the north winze, which is the upcast. The north winze does not reach to the surface, and no air rises "to day" in the mine, the entire current flowing into the Imperial and Bullion mines, both north of the Yellow Jacket, and both of them exclusively upcast.

Captain Taylor has placed Fahrenheit thermometers of the common kind, with japanned tin cases, at the surface, foot of the vertical shaft (1,119 level), 1,732 south and north winzes, 1,935 north winze, and 2,040 south and north winzes. The south winze is downcast, and the thermometers placed here on the different levels measure the increase of heat in the winze itself, while those which are hung at the north winze measure the increase of heat, which each "split" of air gains in moving through 413 feet of drift, that being the distance between the winzes. This fortunate arrangement of the ventilating currents presents the most favorable opportunity I have ever observed for studying the problems involved. The thermometers should be replaced with standard instruments, and the air current measured twice a week for a year, in each drift. The result would be the best series of observations obtainable, probably in any American mine, for the comparative shortness of the paths followed by the air, when contrasted with the long drifts of some coal mines, is compensated for by the high temperature of the rocks, and the marked increase of heat in the air. It is also extremely rare to find the conditions of heat absorption so little complicated by artificial additions.

The air-current entering the mine July 2d, 1877, was measured and found to be 18,140 cubic feet. On the 1732 level the "split" or secondary air-current was found to contain 7200 cubic feet, and for the purpose of illustrating the steady flow of heat from the rock, we may reasonably assume that 18,000 cubic feet of air enter the mine every minute, and that this current is divided into three splits of 6000 cubic feet each, which pass from the south winze 413 feet to the north winze, on each of the three levels, 1732, 1935, and 2040. The second of these is out of consideration, from the fact that there is only one thermometer on it, so that no comparison of the initial and final temperatures can be made.

The following tables contain a summary of all the observations which I have been able to obtain. The record is imperfect on account of the destruction of some tally boards, and this has compelled me to omit some records that are preserved, because the corresponding observations in the same drift are wanting. Where the omission takes place, the figures are included in brackets. The figures given are monthly averages, and the final averages refer only to numbers not in brackets.

Only the observations on the 1732 and 2040 foot levels will be made use of, as these are the only ones where a horizontal air current has its temperature measured at two points in its path. Omitting November from the period of the 1700 foot level and December from that of the 2040 foot level, we have for the average of nine months' observations a difference of temperature between the south and north winzes amounting to

1732 foot level	(89·39° – 78·06°)	11·33° F.
2040 " "	(92·30° – 85·35°)	6·95° F.

This difference represents the heat which the air current has absorbed in passing a distance of 413 feet on these levels. In my report made to Lieutenant Wheeler, and also in a paper on this subject presented to the American Institute of Mining

Engineers, these quantities are given as 10·56° F. and 7·87° F., the difference being due to the fact that they were the average of seven instead of nine months' observations.

Yellow Jacket Mine.—Morning Temperature, 6 A. M.

	Surface.	1119 feet.	1782 feet. S. Winze.	1782 feet. N. Winze.	1900 feet. N. Winze.	2040. S. Winze.	2040. N. Winze.
December, 1876, ...		59·27°	80·23°	92·99°			
January, 1877, ...		52·55	73·42	86·90		85·35°	93·22°
February, "		49·75	76·99	83·71		86·59	93·99
March, "		53·81	78·13	89·20	90·29°	83·68	94·99
April, "		49·87	77·40	88·13	89·97	85·90	93·77
May, "	(44·48°)	53·77	83·42	90·45	90·99	83·39	93·61
June, "	56·07	57·40	79·39	91·47	93·27	88·26	93·63
July, "			(84·00)		94·07		
August, "			(83·23)		94·50		
September, "	56·67	60·80	81·86	91·67	96·60	88·37	92·13
October, "	46·10	55·13	73·65	90·44	92·07	83·23	88·36
November, "	39·90		(76·53)		88·50	81·27	87·23
December, "	35·84						
January, 1878, ...	33·39						
February, "	33·93						
March, "	39·84						
April, "	42·37						
May, "	51·10						
Average, ...	43·52	54·71	78·28	89·48	92·25	85·11	92·33
Time taken, ...	10 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.

Yellow Jacket Mine.—Evening Temperatures, 6 P. M.

	Surface.	1119 feet.	1782 feet. S. Winze.	1782 feet. N. Winze.	1962 feet. N. Winze.	2040 feet. S. Winze.	2040 feet. N. Winze.
December, 1876, ...		59·20°	80·84°	90·92°			
January, 1877, ...		50·77	77·82	86·10		83·23°	93·36°
February, "			76·71	84·03		86·82	93·43
March, "		55·52	74·07	88·58	90·29°	86·68	95·00
April, "		52·83	77·57	88·33	89·93	85·87	93·80
May, "	70·47°	61·50	79·42	91·77	93·03	87·16	93·48
June, "	70·33	61·50	79·40	91·77	93·03	88·20	93·73
July, "			(84·16)		94·29		
August, "			(83·42)		94·29		
September, "	69·13	62·76	81·82	91·11	96·67	87·90	92·00
October, "	54·55	57·30	72·99	91·00	92·10	83·32	88·58
November, "	45·43		(77·40)		89·50	81·13	87·23
December, "	39·58						
January, 1878, ...	38·84						
February, "	37·61						
March, "	44·87						
April, "	52·37						
May, "	60·77						
Average, ...	53·09	57·67	77·85	89·30	92·57	85·60	92·28
Time taken, ...	11 mo's.	8 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.	9 mo's.
Average, morning and evening, ...	48·30	56·19	78·06	89·39	92·41	85·35	92·30

The 1732 level affords us the best evidence that the incessant drain of heat cannot be maintained by supply from a store accumulated in the rock. This drift was probably completed by January 1, 1876, or perhaps some months earlier. It has been constantly in use as an air way, but after this long exposure no diminution in its heating power has been noticed. It has lost the intense heat it had when first opened, but remains at an average temperature of about 90° F.

In other respects I have not observed any circumstances which throw serious doubt upon the thermometer readings. The instruments are not standards, it is true, but they are properly hung on timbers, and usually with ten or twelve inches of wood or air between them and the rock surface. Whenever compared with one of the survey thermometers, hung in the center of the moving air-current, they have not shown a variation of more than one degree. The daily readings are quite uniform, the fluctuations of more than one degree not exceeding twenty-three in a series of about 360 observations. The highest fluctuation noticed is three degrees.

ART. XXXVI.—*United States Geological Survey of the Fortieth Parallel.* Vol. I. *Systematic Geology;* by CLARENCE KING. Reviewed by RAPHAEL PUMPELLY.

THE February number of this Journal contained, in the form of citations, a summary of the results of the Fortieth Parallel Survey in the department of Stratigraphical Geology. The object of the present paper is to present a general review of the more noteworthy results and generalizations, in the other departments.

Quaternary Period.—The Quaternary period of the Cordilleras was contemporaneous with the Glacial and Drift period of the East and of Europe. Its record differs, however, in that no continental glacier ever invaded the Cordillera region to leave, after melting, its immense load of ground-moraine. The climatic conditions which caused the extension of the Scandinavian ice-cap over Northern Europe and of the Greenland ice-cap over Northeastern America produced indeed vast systems of glaciers in the Cordilleras, but they were Alpine ice-streams and as such were localized around the numerous lofty condensing centers and accompanied by the phenomena peculiar to this form of glaciers.

At the east the floods of the Champlain epoch, proceeding from the melting ice, covered the gently graded surface with detritus from the ground-moraine; but the rapid fall of the

Cordillera streams permitted the Glacial floods to form torrents which, aided by the suspended material, cut deep cañons and spread the debris in enormous quantities over the margins of the plains at the mouths of the mountain valleys. An immense amount of erosion was accomplished during the Glacial epoch and there is evidence, to be given below, that it was done during two periods of glacier extension in the Quaternary; during the first and greater the floods cut the deep V-shaped cañons, and during the second the glaciers transformed the upper part of these into U-shaped cañons, and we may add that the second floods deepened the V cañons below the foot of the glacier.

The Great Plains are underlaid by beds which were deposited in a great fresh-water lake. In the southeast these beds dip under the Gulf of Mexico, while near the Rocky Mountains they are 7,000 feet above the Ocean. It is therefore evident that they have been tilted, for otherwise we should have to suppose that there existed a lake whose surface was 7,000 feet above the sea, and for which there was no eastern enclosing wall. Both General G. K. Warren and Mr. King have shown that after the Pliocene such a tilting really took place, so that during Quaternary time this declivity had, as now, free drainage to the Ocean, and was traversed by the rivers flooded from the glaciers.

In the Great Basin the Pliocene—Shoshone—lake was disturbed but not drained off. Its eastern and western edges were depressed 1,500 to 2,000 feet, producing two basins which were occupied by two Quaternary lakes. The eastern one (of which Great Salt Lake is the remnant), extending over 2½ degrees of longitude and 3 degrees of latitude, has been named Lake Bonneville, by Mr. G. K. Gilbert. The western body of water, called by King, Lake Lahontan, occupied about the same absolute range in latitude, with about the same width.

Mr. King infers that the Pliocene lakes were nearly or quite dried up before the Quaternary, because: 1, while the beds contain remnants of only a purely fresh-water fauna, the upper strata sometimes contain deposits of alkaline sulphates and chlorides, that could form in a fresh-water sea only after a nearly complete evaporation; 2, the oldest Quaternary deposits on the sides of the extinct lake basins are subaerial gravels, which were swept by hill-wash and river-floods far out from the parent mountains. During their prime, these inland fresh-water seas were filled to their outlets, Lake Bonneville, over 1,000 feet deep, drained through Red Rock Pass into the Snake and Columbia Rivers. The outlet of Lake Lahontan may have been southward, and the lake must have been over 500 feet deep.

From the fact that the sediments of these lakes are underlaid and overlaid by subaerial gravels, both King and Gilbert infer that there was a very wet period between two dry periods. But our author goes much further, and from the results of a study of the chemistry of the waters, as expressed in the soluble contents of the remaining lakes, and in the natural evaporation products, constructs an ingenious and it would seem a well-founded hypothetical climatic history of the Quaternary period. The argument may be briefly outlined. The now dry shores of the ancient Lake Lahontan are in many places covered, sometimes twenty to sixty feet deep, with a tufaceous deposit, which is often distinctly crystallized and then shows the very characteristic forms of gaylussite—a hydrated carbonate of soda and lime. But chemical analyses show that the soda and water are gone, and that the mineral is now calcite—only the external form being that of gaylussite. In short, we have here an instance of pseudomorphism on a large scale. This pseudomorphous material King calls *Thinolite.* Near Ragtown, Nevada, in a lake which is one of the remnants of Lahontan, and which is presumably fed by springs, the forming of gaylussite can now be seen in operation. It is a dense water very rich in soda carbonate, and when the lake shrinks during the dry season, gaylussite crystals are deposited on the beach and on floating organic substances. Both the facts at this lake and Fritsche's experiments show that gaylussite can form only in the presence of a large excess of carbonate of soda. When the saline water of this lake is diluted during the wet season, the gaylussite is dissolved again.

The thinolite tufa occurs up to an altitude of 470 feet above Pyramid Lake, or within thirty feet of the highest known level of the extinct Lahontan Lake. The inference from this is that the lake must have been long exposed, without an outlet, to concentration by evaporation, and perhaps by contributions from alkaline springs, in order to deposit gaylussite at such an altitude; and, in order to have formed the vast deposits of tufa —originally gaylussite—the lake must have almost wholly evaporated. Now the evaporation of a sea, which, with a depth of 470 feet, was sufficiently saline to deposit gaylussite, would leave its residuary lakes in the condition of saturated solutions; but the fact is that the larger relics of Lahontan, viz: Pyramid and Winnemucca Lakes are sufficiently fresh to support numerous fishes, including one or two of the *Salmonidæ.* It is evident, therefore, that the residuary water of the evaporation of Lahontan, that produced these tufas, must have wholly disappeared. This could only take place by the basin filling to its outlet and remaining at that altitude long enough for its dissolved salts to drain off and for the water to become thoroughly freshened, after which a rapid evaporation brought about the present condition of things.

This argument places before us what seems unimpeachable evidence of the existence of two periods of great humidity and three of desiccation. These several periods King correlates as follows: the first dry period was at the close of the Pliocene; the two wet periods correspond to the two phases of maximum extension of the glaciers and were contemporaneous with the great ice epoch and the Reindeer ice epoch of Europe; the intermediate dry period corresponds with Newberry's Forest-bed horizon; and the last dry period still continues.

During the intermediate dry time there was probably less vegetation even than now in the Cordilleras and on the Great Plains, and it was probably then, that the greater portion of the lœss of the Missouri and Mississippi valleys was transported to its present position by the west winds as the present writer has shown elsewhere.

The well known fact that the surface of Great Salt Lake is rising—it has risen 11 feet since 1867—has been generally ascribed to the cultivation of the surrounding region. Mr. King shows this to be a wrong inference, for a similar increase has affected all the lakes of the Great Basin. He shows partly from observations connected with the growth of trees on the Sierra, that this is due to a climatic oscillation that began about 1860 and which was the first of its kind and extent that has occurred within at least 250 years. This question of oscillation of climate is full of importance to the populations that are pouring into the regions of the Great Plains during the present moist extreme.

Origin of crystalline schists and granite.—Some space is devoted in this volume to the presentation of original hypotheses explaining the origin of crystalline schists and granitic rocks, of fusion in the interior of the globe, and the cause of varieties in volcanic rocks and the law of succession in eruptions.

Mr. King sees in the crystalline schists beds of sedimentary material in which the change that has taken place has been confined to a re-arrangement of the constituents and the obliteration of the interstitial spaces between the detrital particles. Thus purely silicious beds remain as quartzites, lime beds as marble, and mixed sediments as the various compound crystalline schists. The sediments were penetrated with the original saline solutions of the sea and the metamorphism was effected under great pressure and moderate heat but in the absence of fusion. This is proved by the total absence of the microscopic glass-particles that all volcanic rocks show, and by the abundance of cavities containing fluids and salts that the microscope reveals in almost all metamorphic rocks. There was no fusion, although it is possible that the temperature of fusion existed but was prevented by the counteracting pressure from producing liquefaction. The hypothesis is summarized thus:

Conditions of metamorphism.—1. There is a horizon below the surface, at a depth which increases with the secular cooling of the globe, at which the heat and pressure are sufficient to produce the chemical activity needed to effect metamorphism. 2. This horizon sinks deeper with the secular cooling. 3. So long as this horizon is within the depth to which sediments are brought down by displacement of the crust and subsidence, so long will crystalline schists be produced. 4. When by secular cooling the horizon of requisite temperature shall have sunk below the possible levels to which sediments can be depressed, then forever afterward the formation of crystalline schists is ended in that segment of the crust.

Out of gneisses thus formed, Mr. King derives the structureless granitic rocks by the action of tangential pressure. During the horizontal compression due to the shrinkage of the globe, there acts also gravitation. Now when the tangential was slight compared with the down-pressing action of gravitation the schists were simply corrugated; but when the tangential was largely in excess, then the structure of the schists was destroyed and the constituent minerals were to a great extent broken up. This is supposed to account for the granitic rocks and all the transitional forms between these and the corresponding gneissoidal varieties.

Genesis and Classification of volcanic rocks.—In regard to the origin of volcanic rocks, Mr. King argues as follows: The temperature of the earth increases from the surface downward; and owing to the rapid conduction in the outer part of the crust, the rate of increase is very rapid at first and then very slow. Pressure also increases from the surface downward, but, owing to the increase in density, the rate of increase is smallest near the surface and more rapid in depth. Now the action of pressure is directly antagonistic to fusion—increase of pressure raising the melting point. It is therefore evident that a comparison of the strength of these two forces—for and against fusion—will show that the resistance offered by pressure to fusion will be least at the point of maximum rate of increase of temperature, and that from that point down the more rapid rate of increase of pressure than of temperature, renders fusion more and more impossible. The position of this point, or *couche*, in which pressure offers least resistance to fusion must be near the surface. The observed rate of increase would indicate that at a depth of about fifty miles the temperature would produce fusion of rock if not prevented by the pressure. Now if by removal of the superincumbent material the pressure on any given point is diminished at a more rapid rate than that of the cooling of the *couches* below, and if this removal of pressure proceed far enough, fusion must take place; and, being localized, it will form subterranean lakes of molten rock. This *couche* of possible fusion, like all the isothermal and isobaric *couches*, must be parallel to the surface and must rise in ridge-form under mountain ranges. And it is in the active erosion that takes place in mountains that Mr. King finds the means of diminishing the pressure. One of the first objections, that would be advanced to this, would be that erosion does not act with sufficient rapidity. But our author would probably point, and with reason, to the vast accumulations of detrital sediment—thousands of feet thick and covering hundreds or thousands of square miles—which have formed during single geological epochs. During the Cretaceous there accumulated from one to one and one-half miles in thickness of detrital sediment which probably occupies now a larger area than that from which it was eroded, and the following Eocene and Miocene epochs witnessed the enormous outpourings of lava.

In these subterranean lakes of fused rock, are differentiated the varieties of volcanic rocks. Baron Richthofen, after a critical study of volcanic products in Europe, Asia, California and Nevada, proposed a classification of them into propylite, andesite, trachyte, rhyolite and basalt, and stated that wherever several of them occurred in one district the chronological order of their eruption was that in which we have named them. This generalization has been amply corroborated by the 40th Parallel Survey and extended. For Mr. King finds that there is a sufficient persistence of occurrence among the sub-varieties to justify the subdivision of each of Richthofen's "orders" into an acid, a mean and a basic variety (or species) as, for instance, quartz-propylite, hornblende-propylite, augite-propylite, quartz-trachyte, mica-trachyte, augite-trachyte, etc. He goes further, and brings rhyolite and basalt together as the acid and basic extremes of a new order, "neolite."

Now the observations of his survey show that there is a regular order of succession in the eruption of sub-varieties; that when all the varieties of an order appear, the mean was ejected first, then the acid, and last of all the basic. This sequence is explained thus: Fusion, being a function of erosion, is ephemeral, the duration of fluidity being limited by the sinking of the isotherms. Each molten lake must therefore pass through a series of phases which may be stated as follows: 1st, fusion; 2d, crystallization of constituent minerals; 3d, separation, by specific gravity, into a basic, lower *couche* and an acid, upper *couche;* 4th, re-solidification by the reëstablishment of the ante-fusion relation between pressure and temperature.

Now if eruption takes place before the separation, the lava will have a mean composition; as separation takes place the uppermost, or acid, layer is ejected; finally the acid *couche* cools first on account of its higher melting point and higher position, and eruption at this period forces up the basic lava from the *couche*. This is the sequence for King's subdivisions of the different genera; the observed sequence of the genera themselves, i. e. of Richthofen's orders, he explains by supposing them—if we understand him rightly—to represent, from propylite to neolite, each a lower horizon, the depths being determined by the time-intervals; and the differences in character and mean constitution being expressions of the varying of the conditions at increasing depths.

The argument of which this sketch gives only the salient points is undoubtedly, in the writer's opinion, the most consistent hypothesis—the nearest approach to a satisfactory theory—that has been thus far advanced to explain the complicated system of related phenomena under consideration.

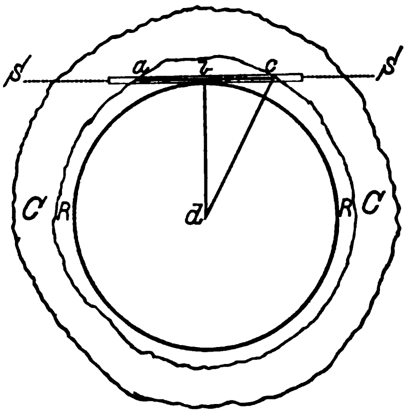
Mountain-building.—In the last chapter there is a review of the conspicuous disturbances of the crust, showing that from the Laurentian to the Quaternary there have been, within the area of the Survey, thirteen periods of mountain-building activity. "In this complicated history . . . . have occurred both upheaval and subsidence as related to the sea-level; plication, always greatest at the western edge of the disturbed area; the formation of folds forty thousand feet from summit to base; the development of faults with at least forty thousand feet of dislocation; the tilting of horizontal regions into broad inclined planes without disturbance, and the division, by complicated fault-systems, of wide areas into numerous separate blocks, of which some are depressed below the level of their adjacent companion blocks." "It is also a general law that those regions which experience elevation without local disturbance are the regions of relatively thin sediment superposed on a comparatively unaccidented Archæan foundation, whereas those which suffer the extremest plication are covered by the thickest deposits overlying and adjacent to the greatest Archaean Mountain ranges." The instances of paroxysmal depression are found to have affected areas immediately after the removal from them of immense thicknesses of material: while the instances of gradual depression occur over areas that were being very heavily loaded with sediment.

ART. XXXVII.—*On a Method of Estimating the Thickness of Young's Reversing Layer;* by W. H. PULSIFER.

A PART of my duties, as a member of the Fort Worth Eclipse party, consisted of the spectroscopic observation of the contacts. I used a telespectroscope combining a four-inch Clark telescope of four feet ten inches focal length, and a ten-prism Browning solar spectroscope. The field included the lines between W. L. 6600 and 6300.

At second contact I observed the reversal of the Fraunhofer lines, and was surprised to find the reversed lines shortened at each end, and occupying but about one-third of the width of the spectrum, while the C line was not shortened and remained in view after the other lines had disappeared. At the moment no explanation of the phenomenon presented itself, but afterward it occurred to me that it was occasioned by the extension of the slit of my spectroscope beyond the reversion layer on each side, and that a measurement of the image of the sun formed on the slit, and of the length of the slit itself, would enable me to estimate the thickness of the reversing layer. Careful measurement showed the diameter of the sun's image on the slit to be $0{\cdot}54^{\text{in.}}$, and the length of the slit $0{\cdot}08^{\text{in.}}$.

In the diagram, C represents the chromosphere, R the reversing layer, S the slit, *a b c* the shortened lines, and *d b* the radius of the sun. The difference in the length of the lines *d b* and *d c* represents the minimum thickness of the layer, as indicated by the reversed lines observed. Assuming the sun's diameter to be 860,000 miles, and accepting the measurement of the sun's image and of the slit, and the statement that the reversed lines occupied but one-third of the width of the spectrum, the difference in the length of the lines *d b* and *d c* is found to be 524 miles.



ART. XXXVIII.—*The Lower Jaw of Loxolophodon*;* by HENRY F. OSBORN and FRANCIS SPEIR, Jr. With a Plate.

LITTLE has been known hitherto of the real character of the lower jaw of Loxolophodon, a genus which together with Uintatherium forms at present the Sub-order Dinocerata. To the literature which has appeared upon the lower jaw of the Dinocerata, Professor Marsh has contributed in this Journal (III, vol. xi, page 163), a description of a specimen of *Uintatherium* (*Dinoceras*) *laticeps* lacking only the canine-incisor series, and it is safe to say that the general characters of this jaw are also applicable to all the known species of Uintatherium; Professor Cope (Proc. Am. Phil. Soc., Feb. 21, 1873) has given a partial description of the lower jaw of Loxolophodon from fragments which were wanting in the most essential features, leaving a wide gap in our knowledge of this important genus.

The following description is based upon specimens collected in the South Bitter Creek country of Wyoming, about fifteen miles south of Laclede, a station on the old overland road. The horizon is considered by King, Cope and Hayden as belonging to the Bridger Series, which here overlies conformably the Vermillion Creek group. The material comprises two jaws, the first found with a large canine-tusk belongs, without doubt, to *L. cornutus;* the second is smaller, possibly of a female of the same species; together they give basis for a complete study, save of the coronoid process which is lost in both. The accompanying plate figures the former specimen, the incisor-canine series have been placed in position from the latter specimen, in which the alveoli are preserved.

General character of the jaw.—One of the most surprising features of the Dinocerata is the disparity existing between the size and strength of the lower jaw, and the large and formidable head. This is even more marked in Loxolophodon than in Uintatherium, for in general contour the lower jaw is neither long nor deep. In *L. cornutus*, the species in hand, it extends from the well-advanced glenoid cavity barely to the tips of the slender premaxillaries, where it is wholly overhung by the broad and projecting nasals, giving it at once an undersized appearance. The rami are shallow and of equal depth throughout; forward they are wholly in the vertical plane, but behind the molar series they diverge considerably below. The angle of the ramus is not prominent; nearly in a vertical line above this is the condyle. The symphysis is long and narrow. The

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*** This article is the first of the second series of Paleontological Bulletins upon the Eocene fauna of Wyoming, to be issued from the E. M. Museum of Princeton College.**

downward processes below the canine-molar diastema are not strongly marked. The molar series are nearly parallel.

Detailed description.—The ramus swells for the coronoid process close to the lower border, and immediately in front of the rise is the nearly straight molar series. The coronoid rises well up into the temporal fossa, judging from its great thickness below. Slightly above the plane of the molar series are the condyles; they are small, decidedly convex, directed backward and slightly upward with their transverse axes converging. Below these the posterior border narrows and is concave, thickening again into the rough rounded angle which projects slightly back of the condyles. The smooth lower border is nearly straight from the angle to below the first premolar, arching but slightly downward; here it both broadens and deepens and interiorly forms a slightly concave surface extending toward the symphysis, exteriorly it has a process homologous to the pendant process in Uintatherium. This arches gently downward and outward, at an angle probably coincident with the projection of the superior canines; when the jaws are in position it falls not half an inch below the deepest portion of the rami. The downward processes in Loxolophodon are then by no means a distinctive feature of the jaw; on the contrary when compared with *U.* (*D.*) *laticeps*, or when placed side by side with the robust process of the lower jaw of *U. Leidianum* in the E. M. Museum, they show a disparity in size, that seems unaccountable in genera so closely allied.

The dental foramen is large and is situated on a line with the molar series. The mental foramen is double and placed just beneath the canine.

At the chin we find the most peculiar modification of the jaw. The processes, as seen from below, have a more outward than downward direction, forming at the posterior half of the symphysis a broad, slightly concave floor, about six inches in width; below the lateral incisor they disappear, and the chin narrows into a prow-shaped keel. The inner margin of the canine-incisor alveolus is well raised, giving the series the appearance of being placed on the side of the jaw. The alveolus is highest at the canine, and dips downward in front; this would throw the teeth greatly out of the horizontal line, were it not that the dental series increase rapidly in size forward. The teeth are arranged not in a semicircle, but in converging lines two and a half inches apart at the canine and in contact at the median incisor; thus the chin is contracted towards its extremity above as well as below. Between the dental series in front and the high thin borders of the diastema behind is the deeply concave floor of the mouth.

Measurements of the lower jaw.

	M.
Extreme length from infra-condylar depression to symphysis	·295
Depth at last molar	·08
Internal depth of jaw at posterior edge of symphysis	·071
Thickness of jaw at angle	·014
" " at first premolar	·036

The molar series (fig. 2) display three transverse crests, the anterior the most prominent, and forming with the second an open angle, with the apex directed inward; the posterior crest less prominent than the other two, is serrate throughout the series. A cingulum, faint elsewhere, is quite strongly developed at the edges of the third crest. Just beyond the inner apex of the middle crest is a large accessory tubercle which is constant on the true molars and last premolar inclusive.

Beginning the detailed description with the last molar, for it has the characters of all the others in strongest development, we find it is by far the largest of the series. The posterior crest attains its greatest elevation at the center. The middle crest marks two valleys, an anterior and a posterior; the latter dips from a central elevation, corresponding to the highest part of the posterior crest, to the cingulum on either side. Of the two valleys the anterior, which slopes from the apex strongly outward, is narrower but deeper. The anterior crest is nearly horizontal, concave on its forward surface, terminating interiorly in a prominent and exteriorly in a lesser tubercle.

The second molar presents the same characters as the last, but is greatly reduced in size; this disparity is more marked here than it is between any two of the other teeth. The first molar is so much more worn that it fixes three as the number of true molars without doubt.

In the premolar series the anterior crest is relatively more prominent and its terminal tubercles become equal in size. The posterior crest extends more on the inner side of the crown. The third is the only one of the premolars on which the tubercle beyond the apex is found. The second and third premolars have the middle crest comparatively lower, while in the first it rises to form a continuous course with the anterior, giving a crescentic appearance to this portion of the tooth, accompanied by a considerable elevation of the outer marginal tubercle.

The canine incisor series.—Owing to the fragmentary state of the mandible of Loxolophodon found by Professor Cope in the Mammoth Butte beds he was led astray as to the lower incisors. In his pamphlet, "On the Short-Footed Ungulata," (Proc. Am. Phil. Soc., Feb. 21, 1873,) he inferred that "the lower incisors must be regarded as wanting. This is in conformity with the structure of the upper jaw and is rendered probable by the great reduction of the symphysis of the lower jaw in this species." Professor Marsh subsequently found the specimen of *U.* (*D.*) *laticeps*, already referred to. In this specimen the alveoli for six lower incisors were found, but the teeth themselves were unfortunately wanting; nevertheless the correct dental formula for the Sub-order was established.

The canines and incisors in *L. cornutus* are contiguous and directed upward and forward at such an angle that the two lobes, larger and smaller, are on a line and divide the attrition. They are placed not in a semicircle but in straight converging lines. They decrease in size regularly backward.

The median incisor (fig. 3) consists of an outer convex and inner flat surface. The outer portion is divided by a median valley into two convex lobes; of these, the anterior is placed higher upon the fang, is much the larger and comes to a pointed apex; a section below the apex would be plano-convex, the plane surface being interior. The median valley, dividing the two lobes externally, rises from the cingulum and is cleft near the top by a slight elevation which is possibly homologous to the median crest of the molar series. The posterior lobe is flatter externally, rises lower upon the fang and comes to an obtuse point about two-thirds the height of the anterior. The inner surface of the tooth is nearly flat, with a slightly raised margin; this throughout, except at the apices of the two lobes, is faintly serrate, and is notched at the summit of the median valley. The second incisor (fig. 4) is shorter and more obtuse than the first but larger than the lateral incisor or canine; in it the notches that mark the upper margin are less distinct; opposite the outer convexities the inner surfaces are more concave. In the lateral incisor (fig. 5) the median valley is deeper and the anterior cleft is less marked, while at the head of the valley the upper margin arches inward; the posterior lobe is relatively higher. In the canine the cleft at the head of the valley has disappeared and consequently there is a deep single valley; opposed to this is a more pronounced convexity of the inner surface. The fangs throughout the series are long, stout, arch forward slightly, and decrease in size with the crowns.

Measurements of the Teeth.

	M.
Entire length of molar series,	·165
Length of true molar series,	·094
Fore and aft diameter of last true molar,	·047
Transverse diameter of same,	·036
Height of crown of same,	·030
Fore and aft diameter of first premolar,	·023
Transverse diameter of same,	·019
Height of crown of same,	·022
Length of canine-incisor series,	·140

Measurements of the Teeth.

	M.
Width of median incisor,	·016
Length of same,	·041
Height of crown of same,	·037
Width of external lobe of same,	·026
Width of internal lobe of same,	·015
Length of fang of same,	·060
Width of canine,	·015
Length of same,	·036
Length of fang of same,	·053

The entire dental series show distinctly two types of structure; the molars are modelled after the last true molar which is the most specialized of the series; while the median incisor is the pattern for the canine-incisor series.

Having now detailed the structural peculiarities of the lower jaw there remains to be shown the important bearing that it has in its general form upon many of the still unsettled questions concerning the habits and type-modification of the Loxolophodon and allied genera. The undersized downward processes are of value in so far as they fully confirm Loxolophodon as independent genus from Uintatherium; they also show that the robust processes of Uintatherium did not have for their object the protection of the upper tusks; otherwise they throw no new light upon the subject at issue. It is around the canine-incisor series that our interest chiefly centers. Immediately the question arises how did these teeth, worn at their tips, strongly directed forward and fixed with stout fangs, meet the upper jaw and how were they of use in feeding. This it seems to us, finds a ready answer when we turn our attention to the premaxillary bones; of these Professor Cope (Proc. Am. Phil. Soc., Feb. 21st, 1873) says: "the premaxillaries do not enclose the very large foramen incisivum in front and are therefore deeply furcate." A careful examination of a fine specimen in the Princeton Museum does not wholly confirm this statement, if we understand it aright. In the posterior half, the premaxillaries are united by a bony plate, and as the inner margin of the anterior half is not a rough line indicating muscular attachment but an irregularly broken edge, it is reasonable to infer that between these bones there was a thin plate of true cartilage in which ossification was certainly advancing at the sides if it never reached the center. These edentulous premaxillaries probably supported a callous pad; if so it is singular that this modification so characteristic of the Ruminants should be found in this formidable aberrant type, especially as it has strong perissodactyle affinities. Now as regards the process of feeding, it is certain that, setting aside the short neck and elevated shoulders, the extreme protrusion of the nasals would not permit of the action of close cropping, and this leaves the only alternative that the animal browsed from the tall reeds and undergrowth which accompanied a moist and tropical climate. These conjectures, if established by more extended research, are valuable in connection with the dispute regarding the proboscidean characters of the sub-order, which occupied many pages in vol. vii of the American Naturalist, for they do away with the necessity for a proboscis, pointing rather to a powerful prehensile upper lip. It will be understood, however, that no more validity is claimed for them than that of mere hypothesis, to be strengthened or broken down by further evidence.

Explanation of plate.—Fig. 1, left lower ramus of *L. cornutus*. Fig. 2, molar series of same. Fig. 3, median incisor. Fig. 4, second incisor. Fig. 5, lateral incisor. Fig. 6, canine. The ramus is drawn one-third natural size; the remaining figures are two-thirds natural size.

ART. XXXIX.—*Notice of recent Additions to the Marine Fauna of the eastern coast of North America, No.* 4; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLI.

IN the following notice there will be found descriptions of new species of Hydroids, belonging to the *Plumularidæ*, referred to in the preceding number, but from which they were omitted, for lack of space. These and other species herein named, as well as those described in the last number, form part of the extensive collections of marine Invertebrata, belonging to the U. S. Commission of Fish and Fisheries, which have been entrusted to me for examination and description, by the Commissioner, Professor S. F. Baird. In the present notice, there are also included certain species which were collected during several special dredging expeditions, undertaken by the author, with Professor S. I. Smith and others, in 1864, 1865, 1868, 1870, previous to the organization of the Fish Commission.

HYDROIDA.

Cladocarpus Pourtalesii, sp. nov.

A large species, forming a tall, unbranched, secund plume. Hydrocaulus stout, compound, rough; the component tubes run in an irregular subspiral course, and each bears two rows of nematothecæ. The pinnæ are very numerous, about an inch long, and arise alternately, in one line, along the front of the stem and curve outward and upward. Hydrothecæ about twice as long as broad, only slightly enlarged toward the aperture, which has a smooth even margin; intrathecal septum conspicuous, the free edge curled upward. Lateral nematothecæ short, broad, rising but slightly above the margin of the hydrothecæ; median nematothecæ short, adnate, except close to the end, rather more than one-third as long as the hydrothecæ. The gonothecæ, which are borne on short, jointed, branches arising from the base of the pinnæ, are subcalceoliform, when seen in a side-view, but in a front-view obovate, narrowing to a slender base; aperture lunate, near the end, on one side, the lower lip sunken or incurved. There are one to five gonothecæ on each supporting branch. Color, light yellowish.

Height of largest specimen, 200^{mm}; length of naked part of stem, 40^{mm}; length of pinnæ, 18 to 22^{mm}; diameter of stem, 1·5^{mm}.

S. W from Cape Sable, N. S., 112–115 fathoms, gravel, 1877, U. S. F. Com. Also taken on Banquereau, N. S., in 300 fathoms, by the crew of the schooner "Magic," Capt. W. Thompson.

Cladocarpus cornutus, sp. nov.

Hydroid subpinnately branched, rather rigid, with compound stem. The few branches (four in one example) diverge at a wide angle, and are like the main stem. Pinnæ not crowded, spreading outward abruptly, and somewhat bent backward, about a third of an inch long. Hydrothecæ large, somewhat compressed, adnate to the stem, somewhat triangular or obconic in a side view, expanding from base to rim, with a conspicuous median keel or ridge along the front, which rises into a prominent, lanceolate, acute lobe projecting considerably beyond the lateral borders, which are divided into about five, often unequal, obtuse, subangular lobes, a small incurved lobe being situated each side of the base of the large median lobe; intrathecal septum narrow, situated near the bottom of the hydrothecæ. Lateral nematothecæ elongated, the ends free, spreading outward laterally, margin crenulated; median nematothecæ short, narrow, tapering, directed outward, with the mouth very oblique, and margin crenulated, free for about half their length, and not extending so far as the middle of the hydrotheca. Each joint of the pinnæ is divided internally into five or six compartments by transverse septa. Gonothecæ swollen, obovate, borne on the mid-rib of the main stem and principal branches, at the bases of short, jointed, special protective branchlets, either simple or forked, many of which have a single hydrotheca, of the ordinary form, on the last joint, but only nematothecæ on the others. Dark horn-color.

Height, 70^{mm}; length of longest branch, 20^{mm}; length of longest pinnæ, 8 to 9^{mm}.

Off Sable Island, N. S., on Banquereau, in about 200 fathoms. Obtained by the crew of the schooner "Marion," Capt. J. W. Collins, Sept. 12, 1878, and preserved by Mr. Newcomb.

Cladocarpus speciosus, sp. nov.

Our single specimen is small, unbranched, without gonophores. Stem compound. Pinnæ slender, not crowded, spreading at a wide angle. Hydrothecæ rather short, slightly campanulate, in a side view the breadth of the aperture is equal to two-thirds the depth; a faint median ridge on the front; the margin is divided rather regularly into about eleven or thirteen, moderate sized, subacute teeth, the outer median tooth, and that next to it, on each side, a little longer than the rest; intrathecal septum well-developed, near the bottom; lateral nematothecæ short, swollen in the middle, narrowed to the aperture, margin crenulated; median nematothecæ short, adnate, except at the end, where the oblique aperture faces the hydrotheca, margin crenulated.

Height, 26^{mm}; length of pinnæ, 10^{mm}.

Banquereau, off Sable Island, N. S., in about 200 fathoms, with the preceding species.

MOLLUSCA.

Cingula Jan-Mayeni nob.

Rissoa Jan-Mayeni Friele, Nyt Mag. for Naturvidensk., 1877, Jan-Mayen Mollusca, (author's copies, p. 4, figs. 4 a, b.)

Several specimens of this species were sent to me by Mr. J. F. Whiteaves, who dredged them in 1873, in the Gulf of St. Lawrence, 200 fathoms, mud. It is recorded as from 70 to 300 fathoms, off Greenland, by Friele. It is allied to *C. arenaria* Migh. (=*R. scrobiculatata* Möll.) and to *C. carinata* Mighels, but is a larger and stouter species than either of these, with stronger sculpture and more angular and shouldered whorls. The color is dark chestnut-brown. There are, in our specimens, four strong revolving ridges on the last whorl; the upper one nodulous; the lowest, stout, basal; about fourteen transverse subsutural costæ, extend to and join the first revolving ridge, giving rise to the small tubercles. On the spire only two spiral lines are visible. Length, 4^{mm}; breadth, $2{\cdot}5^{mm}$.

Cingula areolata nob.

Turritella areolata Stimp., Shells of New England, p. 35, 1851.

This species, which has long been lost sight of, and even omitted from Binney's Gould, I have recently rediscovered among small shells dredged at Mt. Desert Island, coast of Maine, about 1860, by the late Professor Wm. C. Cleveland, and also among the shells from the Gulf of St. Lawrence, sent by Mr. J. F. Whiteaves, who dredged it in ninety-six fathoms, in Trinity Bay. It is allied to *C. carinata* Mighels, but is a more delicate, longer, and more pointed shell, translucent, and nearly white in color, and has a smooth base. It somewhat resembles a minute *Scalaria*. The six whorls are well-rounded, with deep sutures; the last whorl has four or five delicate revolving ridges, around the middle, but none on the base; the numerous and regular subsutural ribs cross two or more of the revolving ridges. The aperture is slightly angular and effuse in front, or sometimes even slightly notched. The inner lip is scarcely continuous posteriorly, or represented only by a very thin deposit on the body-whorl; no umbilicus. An examination of the soft parts and of the dentition shows that this is a genuine *Rissoa*, (as understood by Jeffreys and others, in the wider sense). But it seems to me better to adopt the name *Cingula*, as restricted by Gould, in 1841, for those species, mostly northern, which lack the opercular cirrus, and which, also, usually have thin shells, with no distinct rib on the outer lip. To this group belong nearly all our other New England species, viz: *C. aculeus* Gld., *C. multilineata* (St.), *C. castanea* (Möll.), *C. arenaria* M. (=*R. exarata* St.), *C. carinata* M., *C. latior* M., *C. globulus* (Möll.). No true *Rissoa* has yet been found on the Northeastern coast of America.

Cingula castanea nob., (=***Rissoa castanea*** Möller).

This species I have dredged at Eastport, Me. (1864). Professor Cleveland took it at Mt. Desert, Me.; and Mr. Whiteaves in the Gulf of St. Lawrence. It is sometimes white.

Acirsa costulata nob., (=***Turritella costulata*** Mighels, 1841).

The species, very well described and figured by Mighels, is undoubtedly identical with *A. borealis* Beck, MSS., and *A. Eschrichtii* (Möll. 1842) of authors. The name given by Mighels appears to have priority of publication. It is not uncommon off the coast of Maine, in 10 to 90 fathoms.

Leptochiton alveolus (Sars) Lovén.

Mr. W. H. Dall has detected this species among specimens dredged in the Gulf of Maine, in 150 fathoms, by Dr. A. S. Packard, for the U. S. Fish Commission, on the "Bache," in 1872. He also informs me that he has received it from the Gulf of St. Lawrence, 220 fath., (Coll. Whiteaves).

Leptochiton cancellatus (Sby.) H. & A. Adams.

Mr. Dall has identified, as probably of this species, an immature specimen dredged by me, in 1877, off Halifax, N. S., in 95 fath., while on the U. S. Fish Commission.

Doris repanda Alder and Hancock, (=***D. planulata*** Stimpson).

A critical examination of the dentition of this species shows that the American specimens are perfectly identical with the European.

Acanthodoris ornata Verrill, sp. nov.

Length about 1 inch, or 25mm; breadth 8mm. Body elongated, high at the sides, somewhat oblong; but narrower and obtusely rounded behind, extending much beyond the mantle; mantle much smaller than foot, broadly rounded in front, and expanded into rounded antero-lateral angles, narrowed and often incurved in middle and again expanded opposite the gills, covered with small, conical papillæ, except on a smooth area on the middle of the back, extending from the gills to the tentacles. Frontal veil broad, angular, with four distinct, but small, papilliform processes, two directed forward and two at the prominent outer angles. Dorsal tentacles long, slender, tapered at the end, length, nearly equal to breadth of body (6mm), the lower half smooth, the distal half with about sixteen strong lamellæ, and a terminal rounded papilla; sheaths rudimentary, with very small papillæ. Gills eight, large, broad, in expansion exceeding the breadth of the body, bipinnate, finely divided, the two posterior ones smaller, all united by a basal web; anal area smooth. Color, translucent yellowish flesh-color, specked with yellow and brown; bases of papillæ surrounded by brown; dorsal smooth area brownish (due to viscera); gills pale flesh-color, with flake-white at their bases; tentacles pale, their lamellæ brownish yellow. (Description from living specimen).

Eastport, Me., at low water, Aug. 19, 1872. Collected by the writer while with the U. S. Fish Commission. Drawings were made by Mr. Emerton, and the writer.

Allied to *Doris* (*Acanthodoris*) *subquadrata* Alder and Hancock.

Acanthodoris stellata nob., (=*Doris stellata* Gmelin.)

Doris (*Acanthodoris*) *pilosa* Alder and Hancock, Plate 15, figs. 1–10 (*non Doris pilosa* Müller).
Doris bifida Verrill, this Journal, vol. 1, p. 406. (Variety).

Typical specimens of this species have been repeatedly collected and carefully examined by me, from various parts of the New England coast (New Haven to Eastport, Me.), and agree perfectly with the figures and descriptions by Alder and Hancock, except that the white stellate markings on the gills are usually absent. My *Doris bifida* is only a color-variety.

Acanthodoris citrina sp. nov.

At Eastport, Me., I have observed a more distinct form, probably a new species. In this the body is more depressed and elongated, elliptical; the frontal veil is crescent-shaped, with the angles much produced, and with two, more prominent, tentacular papillæ in front. Mantle covered with small, soft, conical, acute, yellow papillæ, with yellow granules between them. Branchiæ nine, broad, bipinnate and tripinnate, in expansion nearly reaching the sides of body, the two posterior small, all united beneath by a short web. Color, pale lemon-yellow, specked with bright yellow; gills yellow; tentacles and edge of mantle orange. Length 25^{mm}; breadth 8 to 10^{mm}.

Adalaria proxima Bergh, (=*Doris proxima* Alder and Han.)

Specimens of this species were collected at Eastport, Me., by the writer and Professor S. I. Smith, in 1864, and also in subsequent years. They agree perfectly, both in external characters and dentition, with the English specimens.

Onchidoris muricata (Müller). H. and A. Adams.

Specimens, apparently identical with this species, were obtained at Eastport, Me., with the preceding.

Onchidoris diaphana (Alder and Han.)

Not uncommon at Eastport, Me., where I obtained it in 1864, '68, '70, at low-water, under stones.

Coryphella rutila, sp. nov.

A large, brilliantly colored species, remarkable for the small size of the head. Foot broad, pointed, but not much elongated posteriorly; auricles very long, often equal to breadth of foot, slender, acute, with a fold or groove in front. Head small, rounded, often emarginate in front, with the mouth large and subterminal. Oral tentacles arising from sides of head, slender, elongated, tapering, slightly wrinkled; dorsal tentacles slightly stouter and longer, wrinkled, arising near together; eyes not observed. Branchiæ numerous, long, rather slender, slightly fusiform, arranged in eight to ten, usually well-separated, transverse clusters, mostly of two rows each, usually six to eight in each row; anteriorly the clusters become more crowded. Color, yellowish white, translucent; branchiæ with a bright vermilion nucleus, the tips, for some distance, flake-white; dorsal tentacles pale yellowish, usually tipped with white. Length, 48^{mm}; breadth, 7^{mm}; dorsal tentacles, 10^{mm}; oral, 9^{mm}; branchiæ, $9{\cdot}5^{mm}$.

Eastport, Me., 1864, 1868, 1872, found at low-water, sometimes under stones, but often entirely exposed, creeping over algæ. It is allied to *Æolis pellucida* Alder and Hancock.

Cuthona Stimpsoni, sp. nov.

A species of *Cuthona*, allied to *C. Peachii* Ald. and Han., is not uncommon at Eastport, Me., where I have observed it in 1865, '68, '70 and '72. The tentacles of both pairs appear to be longer than in the English species, and the head to be more produced laterally. The foot is broad, not very acute nor slender posteriorly; auricles small, short, triangular, often directed backward. The head is large, broad, rounded in front, with distinct rounded lateral lobes. Tentacles slender, slightly wrinkled; branchiæ numerous, crowded, fusiform. Color, yellowish white, with a flake-white line on the upper side of foot, posteriorly; tentacles tinged with salmon, with flake-white specks or a streak, distally; branchiæ with salmon, yellowish brown, reddish brown, or purplish nucleus, and specked at the end with flake-white, which sometimes forms a ring, near the tip. Length, 10 to 32^{mm}.

Art. XL.—*On the Presence of Chlorine in Scapolites;* by Frank D. Adams. *Contributions from the Laboratory of the Sheffield Scientific School.* No. LIV.

In the present paper I wish to call the attention of mineralogists to a fact which appears to have been hitherto almost entirely overlooked, namely, the presence of chlorine in minerals of the scapolite family. In a paper which appeared in the Annalen der Chemie und Pharmacie, xlvi, p. 340, 1843, Dr. Carl Schafhäutl details the results of his examination of "Porzellanspath." It was called passauite by Naumann, and classed in Dana's Mineralogy as an altered ekebergite. The mineral was first analyzed and made a distinct species by Fuchs, who, in his Mineralogy, published in 1842, assigns to it the formula

$$4\bar{\text{Al}}\,\dddot{\text{Si}}+4\dot{\text{Ca}}\,\dddot{\text{Si}}+\bar{\text{Cl}}\,\text{Na},$$

which requires 7·83 per cent of sodium chloride. He, however, supports the formula by no analyses. Dr. Schafhäutl employed several methods in determining the chlorine. In one, the powdered mineral was heated in a retort with concentrated sulphuric acid and the distillate caught in a tube containing silver nitrate. This method required care, but gave good results. He then tried fusion with barium carbonate, or sodium carbonate. Only a little chlorine was found when a red heat was employed, and none at all when a white heat was given. But a satisfactory result was obtained by fusing with barium carbonate in a very thin platinum crucible, some of the carbonate being placed on top of the mixture, and the heat supplied by a Fuchs spirit lamp. The quantity of chlorine in the mineral was found to be ·924 per cent, an amount just sufficient to saturate the potassium present. From his analysis he deduced the following formula:

$$4(\text{Al}_2\text{O}_3,\ \text{SiO}_3)+\left\{\begin{matrix}2(\text{CaO},\ \text{SiO}_3)\\ \text{NaO},\ \text{SiO}_3\end{matrix}\right\}+\tfrac{1}{5}\text{KCl}_2$$

This analysis of Dr. Schafhäutl's is the only one in the lists of analyses of scapolites given in Dana's Mineralogy, in which chlorine is mentioned as one of the constituents.

This winter a duplicate analysis of a scapolite from lot 13 of the 8th concession of the township of Ripon, Quebec, was made by the writer, but it fell short of 100 by several per cent. Thinking that a loss must have been incurred at some step in the process, the analysis was repeated, but the results were much the same. The mineral was then tested for fluorine by the method described in Fresenius' Qual. Anal., p. 218, 7, but none was found. It was noticed, however, that by heating the powdered mineral alone in a platinum crucible, a heavy sublimate was obtained which collected in a drop on the cover of the crucible. This sublimate was soluble in water, the solution gave a precipitate with silver nitrate and also one with barium chloride, thus showing the presence of chlorine and sulphuric acid in the mineral. A complete analysis of the mineral was again made in duplicate; this time the chlorine and sulphuric acid were determined, and it was found to sum up satisfactorily. The scapolite occurs in veins varying in width from a few inches to a foot. It is associated with blackish mica, green hornblende, colorless quartz, reddish calcite, green apatite, black tourmaline, and frequently incloses small crystals of brownish sphene. The opening from which the specimens were taken was made in search of apatite, which occurs in the vicinity both in crystals associated with blackish mica and reddish calcite, and also in the finely granular form known to the miners as "sugar phosphate." A portion of one of the apatite crystals was examined and found to contain chlorine. The color of the mineral is white, sometimes greenish-white.

The scapolite occurs in rather large crystals, the exterior portions of which are evidently somewhat decomposed, while the interior is apparently unchanged. It fuses with intumescence at about 3. The lustre of the undecomposed mineral on the basal surface of fracture is sub-vitreous, but elsewhere there is little lustre. The only cleavage observed was paralled to the lateral faces, which are deeply striated. Specific gravity of three specimens was as follows:—2·605, 2·654, 2·626. A portion having the strongest vitreous lustre was selected for analysis. A section made from a fragment of this was submitted to a microscopic examination by Mr. Hawes, who judged that the impurities were not present in sufficient quantity to cause any error in conclusions drawn from the results of analysis.* The chlorine and sulphuric acid were determined by fusing with sodium carbonate, and after digesting the fused mass with water, acidifying with nitric acid and precipitating the chlorine by silver nitrate. The excess of silver in the filtrate was then separated by hydrochloric acid, filtered off, and the sulphuric acid precipitated in the filtrate by barium chloride. Since as before mentioned alkaline chlorides are lost by igniting the mineral strongly, the elongated slightly conical crucible designed by Dr. Smith for his alkali determinations, was made use of in estimating the water. The mineral was dried over sulphuric acid in a platinum boat, introduced into this crucible and kept at a bright red heat over a fish-tail Bunsen lamp until it ceased to lose weight. The flame of a Bunsen lamp was occasionally passed across the mouth of the crucible but no yellow coloration was imparted to it, and on rinsing out the crucible with distilled water only a trace of chloride was found in solution. The remaining constituents were determined in the usual way.

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* Minute quantities of orthoclase and calcite were observed. No disengagement of carbon dioxide could be perceived when the powdered mineral was treated with hydrochloric acid.

The results of the analyses are as follows:

	I.	II.	Mean.
SiO_2	54·859	54·858	54·859
Al_2O_3	22·128	22·769	22·448
Fe_2O_3	·486	·486	·486
CaO	9·164	9·020	9·092
MgO	trace.	trace.	trace.
K_2O	1·241	1·013	1·127
Na_2O	8·358	8·373	8·365
Cl	(2·473) 2·485	2·276	2·411
SO_3	·823	·770	·796
H_2O (comb.)	·143	·139	·141
H_2O (hygr.)	·722	·723	·722
	100·409	100·427	100·447
Deduction for O replaced by Cl,	·59	·59	·59
	99·819	99·837	99·857

Assuming chlorine and sulphuric acid to be combined with sodium, the atomic and quantivalent ratios calculated from the mean of the above analyses, are:

	Atomic.	Quantivalent.		
Si	914 × 4	3656		3656
Al	438 × 3	1314	1332	
Fe	006 × 3	18		
Ca	162 × 2	324	324	1886
Na	206	206	230	
K	024	24		
NaCl	068			
Na_2SO_4	010			
H_2O	032			

Excluding NaCl and Na_2SO_4, the quantivalent ratio for basic elements and silicon is 1886 : 3656=1 : 1·94, approximately that required by a bisilicate (1 : 2). It is therefore more acidic than any of the members of the scapolite family with the exception of dipyre and marialite.

As many of the analyses given in Dana's Mineralogy foot up to less than 100, some of them being as low as 97 and 98, it was thought that the deficiency might be due to chlorine, which had been overlooked in the analyses. Accordingly fourteen specimens of scapolite, from different localities, were selected and examined for this element. It was found in every case, though in some of them the amount present was small. They were tested by heating some of the finely pulverized mineral to whiteness in a platinum crucible, by means of a powerful blast lamp, the flame being slanted so as not to heat the upper portion of the crucible more than necessary. The sublimate obtained on the cover was dissolved in water and the usual tests applied. In the following table the percentage results of the examination of the scapolites are tabulated. A dash indicates that the constituent referred to has not been tested for.

	Chlorine.	Sulphuric Acid.	Loss on ignition at a red heat.	Carbonic Acid.
Gouverneur, N. Y.	Cl. pres.	——	——	None.
Lewis Co., N. Y.	" "	——	——	——
Edenville, Orange Co., N. Y.	" "	——	——	CO_2 pres.
Monroe, Conn.	" "	——	——	——
Bolton, Mass., (Pink scap.)	" "	——	——	CO_2 pres.
" " (Whitish ")	" "	——	——	" "
Pierrepoint, N. Y.	" "	H_2SO_4 pres.	——	——
Meionite, Mt. Somma, Italy.	" "	" "	——	——
Arendal, Norway.	" "	" "	——	CO_2 pres.
Malsjö, Wermland, Sweden.	" "	" "	——	" "
Templeton (21st lot of 12th range) Queb., massive and banded.	" "	" "	——	" "
Ripon (13th lot of 8th range) Quebec. High lustre.	2·411	·796 (SO_3)	·722	None.
Ripon (13th lot of 8th range) Quebec. Less lustre.	1·468	——	1·496	CO_2 pres.
Ripon (13th lot of 8th range) Quebec. Less lustre.	2·011	——	——	" "
Hull (8th lot of 14th range) Quebec.	·2026	H_2SO_4 pres.	——	" "
Trumbull, Conn.	(?) 1·783	——	·337	None.
Kokken, near Krageröe, Norway.	2·013	H_2SO_4 pres.	(?) 1·903	CO_2 pres.
Passauite, Passau (Schafhäutl.)	·924	——	1·2 (water)	——

Dr. B. J. Harrington informs me that he has found chlorine in other scapolites from the township of Templeton, Quebec, both in crystallized and massive specimens, though he has not determined the amount present. When the mineral contains only a small quantity of chlorine, as in the cases of the specimens from Arendal, Malsjö and Templeton, it cannot be detected with certainty by igniting the mineral, but it is easily found by Rose's method, which will be mentioned farther on. In order to ascertain what quantity of chlorine must be present in the mineral to be detected by the ignition test, the scapolite from

Hull, which gives off only a trace on ignition, was examined by Rose's method and found to contain ·202 per cent of chlorine. It is therefore probable that those specimens, whose sublimate gave a distinct precipitate with silver nitrate contained above that amount. In every case in which the sublimate was tested with barium chloride, a white precipitate was obtained. In the scapolite from Ripon this was due to sulphuric acid contained in the mineral, but in other cases it may possibly have been due to fluorine. The blue sodalite occurring at Litchfield, Me., loses alkaline chlorides when ignited, in the same manner as the scapolites. The sublimate contains a trace of sulphuric acid in addition to the chlorine. A specimen of wilsonite, from Bathurst, Ont., when subjected to the same test, gave no sublimate, but another specimen of the same mineral from the fifth lot of the tenth range of Hull, Quebec, gave a slight sublimate which contained a trace of sulphuric acid, but no chlorine. The meionite mentioned in the table gave a comparatively heavy sublimate.

Dr. Schafhäutl, in his paper referred to above, states that his "Porzellanspath" lost all its chlorine when fused with sodium carbonate at a white heat, and that only a trace remained if a red heat was employed. In order to ascertain whether my analysis was deficient on this account, I determined the chlorine in a white scapolite from Trumbull, Conn., both by fusing it with sodium carbonate, over a powerful circular Bunsen lamp, and also by Rose's method. This method consists in decomposing the mineral in the cold by hydrofluoric acid in the presence of weak nitric acid. The calcium fluoride is filtered off, and the chlorine determined in the filtrate by precipitating with silver nitrate. The results were as follows:—

By decomposition with hydrofluoric acid.........	1·824	per cent.
By fusion with sodium carbonate..........	1·756	"
Difference.........................	·068	

The loss is therefore very small. The scapolite from Ripon is not easily decomposed by sulphuric acid. In an experiment conducted by Mr. Comstock in this laboratory, two grams of the finely pulverized mineral were treated with concentrated sulphuric acid for three hours and a half at a temperature between 160° and 200° C., but only a trace of chlorine was given off. Dr. Schafhäutl also states that at a red heat every trace of chlorine was expelled from his mineral, and that some of the chlorides were dissolved out by water. That such is not the case with all scapolites is seen from the following experiments conducted on the same material from Ripon: ·87 of a gram was heated to intense whiteness in a platinum crucible and fused down to a transparent, colorless, vesicular mass. It lost 5·178 per cent, but the residue gave a heavy precipitate with silver nitrate when examined by Rose's method. It was found that only a very small quantity of the chlorides escaped at a high red heat, a white heat being required to expel them in large quantity, although even at that temperature some remain as proved by the last experiment. About half a gram of the finely powdered mineral was treated with cold distilled water for about forty-five hours, but not a trace of the chlorides went into solution. The scapolites mentioned in the table, which contain the highest percentage of chlorine, are generally sound and undecomposed. Two specimens of the Ripon mineral, with little or no luster, were found to contain less chlorine than an undecomposed specimen with a high lustre. Fuchs states that the "Porzellanspath," examined by him, lost a portion of its chlorides on decomposition. The specimen from Hull, which contained only ·202 per cent, was almost entirely devoid of lustre and contained carbon dioxide. It is therefore highly probable that chlorine is lost, and not gained by the decomposition of the scapolite minerals.

It is possible that in some cases at least the failure of scapolites to give a good formula, may be due to the fact that sufficient alkali to combine with the undetermined chlorine present has not been deducted before attempting to deduce the formula.

My best thanks are due to Professor Allen, who has kindly directed this investigation.

SCIENTIFIC INTELLIGENCE.

I. Physics.

1. *On the Formation of Mountains and the Secular Cooling of the Earth;* by G. H. Darwin.—The letters of Mr. Wallace and Mr. Fisher in Nature, vol. xix, pp. 121, 172, 244, 267, raise the question as to whether or not it is possible that the interior of the earth can be cooling more rapidly than the exterior. The following is an attempt to answer the query as to where the loss of temperature per unit of time is greatest.

Sir W. Thomson (see Thomson and Tait, "Nat. Phil.," App. D) considers the cooling of "a solid extending to infinity in all directions, on the supposition that at an initial epoch the temperature has had two different constant values on the two sides of a certain infinite plane." The solution given is—

$$v = v_0 + \frac{2V}{\sqrt{\pi}} \int_0^{\frac{x}{2\sqrt{(kt)}}} e^{-z^2} dz$$

where k denotes the conductivity of the solid, measured in terms of the thermal capacity of the unit of bulk; V, half the difference of the two initial temperatures: v_0, their arithmetical mean: t, the time; x, the distance of any point from the middle plane; v, the temperature of the point x at time t.

The above solution shows that for all values of the time when $x = 0$, $v = v_0$, so that the temperature at the medial plane is constant.

Then differentiating v with regard to the time we have—

$$-\frac{dv}{dt} = \frac{V}{2\sqrt{(\pi k)}} \frac{x}{t^{\frac{3}{2}}} e^{\frac{-x^2}{kt}}.$$

This expression is that required for the rate of cooling. We now wish to find where it is a maximum. Consider the function $z e^{-z^2}$; this is clearly a maximum when $\log z - z^2$ is a maximum, and by the ordinary rules this is a maximum when $\frac{1}{z} = 2z$, or when $z^2 = \frac{1}{2}$. Hence it follows that $-\frac{dv}{dt}$ has its maximum value where $x^2 = 2kt$. Now when the unit of length is a foot and of time a year, $k = 400$; hence $x = \sqrt{800t}$.

This formula shows that the seat of the maximum rate of cooling moves inward as the time increases. If the time which has elapsed from the initial state be two hundred million years, or $t = 2 \times 10^8$, we have $x = 400{,}000$ feet, or a little less than eighty miles.

Sir W. Thomson shows, in his paper on the Secular Cooling of the Earth, that the solution of his ideal problem will be very nearly correct for the case of the earth, which is supposed to be a hot sphere cooling by radiation. It follows, therefore, from the numerical result which is given above that the seat of the maximum ratio of cooling must probably be something like 100 miles below the earth's surface. It does not, of course, necessarily follow that the seat of the maximum rate of contraction of volume should be identical with that of the maximum rate of cooling; yet it seems probable that it would not be very far removed from it.

The Rev. O. Fisher very justly remarks that the more rapid contraction of the internal than the external strata would cause a wrinkling of the surface, although he does not admit that this can be the sole cause of geological distortion. The fact that the region of maximum rate of cooling is so near to the surface recalls the interesting series of experiments recently made by M. Favre (of which an account appeared in Nature, vol. xix, p. 103), where all the phenomena of geological contortion were reproduced in a layer of clay placed on a stretched india-rubber membrane, which was afterwards allowed to contract. Does it not seem possible that Mr. Fisher may have under-estimated the contractibility of rock in cooling, and that this is the sole cause of geological contortion?—*Nature*, Feb. 6.

2. *On Binaural Audition.*[*]—In a recent number of the Philosophical Magazine (March, 1879), STEINHAUSER discusses the theory of direct Binaural Audition. Some of his conclusions are stated as follows:

(1.) The direction in which a source of sound is situated, may be estimated by the different intensities with which a sound is perceived in the two ears. (2.) The standard of each individual for the perception of the direction of sounds is dependent upon the angle β, that is, the angle included between the effective surfaces of the pinnæ of the ears and the line of sight. (3). The smaller the angle included between the line of sight and the surfaces of the pinnæ, the more certain will be the perception of the direction of sound. (4.) We hear best with the two ears when the sound reaches us from the front in the line of sight. (5.) Persons equally hard of hearing in one ear must, in order to hear as well as possible, turn the better-hearing ear the more towards the speaker in proportion as the angle which the surfaces of their pinnæ make with the line of sight is less. (6.) The power of perception of the direction of a sound is not vitiated by an equal hardness of hearing in both ears. (7.) For most persons the angle β (above defined) is less than 30°, which explains the well-known position assumed by the listener who turns one ear towards the source of sound. (8.) We hear binaurally the best, relatively, when the source of sound is situated in that plane in which are situated the line of sight and the line joining the middle points of the pinnæ ("plane of best hearing") and the best, absolutely, when it is situated in the line of sight. (9.) In the case of hearing a sound coming from above or below, we are able to estimate, from the relative intensities with which the sound is perceived in the two ears, the azimuth of the rays of sound as projected upon the plane of best hearing.

The last principle explains the method which we pursue to discover the position of a source of sound whose situation is unknown, and which consists in a motion of the head.

For example, to find a source of sound situated anywhere *above*, we have only to turn the head about a vertical axis until we hear equally with both ears and with the greatest total intensity. Then the line of sight coincides with the horizontal projection of the direction of the sound. The head must then be turned upwards about a horizontal axis at right angles to the line of sight, as long as the intensity of the sensation increases. When this reaches its maximum, and is equally great for both ears, then the source of sound must be situated in the line of sight. And here we must remark on the essential importance of the actual conditions—that the ears and eyes, being alike attached to the head, share its movements, and that they are situated at almost the same height above the ground.

Should we perceive a falling-off in the intensity of the sound on raising the head, this would be an indication that the source of sound is situated *below* the plane of best hearing, and that we should be able by sinking the head to bring the source of sound into the line of sight in the manner just described for a sound above the head.

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[*] See this Journal, January, 18 9, p. 64.

It is intelligible and natural that, where (as in an instrument for measuring altitude and azimuth) we have two separate motions of rotation at right angles to one another, it is immaterial whether the movements in the two directions be executed separately or by a simultaneous motion of the head. This occurs, for example, when we try to find a lark which we may hear singing above a field. We raise the head, making an arbitrary guess at the position of the lark in the sky. Then we turn the head about, led meanwhile *by ear* until we hear equally well with the two ears and with the greatest possible intensity; and simultaneously we perceive the lark in the line of sight. We do not, therefore, as it might be conjectured in this case, seek for the source of sound by means of the eyes, but *by means of the ears.*

3. *The Faraday Lecture before the Fellows of the London Chemical Society*, November 12, 1878, by Professor AD. WURTZ of Paris, is published at length in the January number of the Journal of this society. The subject chosen was "Constitution of Matter in the Gaseous State," and is significant after the discussions of the fundamental principles of modern chemistry which have taken place in the French Academy, and to which we have before referred in these pages. The lecture was an elementary exposition of the dynamical theory of the constitution of matter, and of the conception of molecules and atoms which this theory involves, and which Professor Wurtz fully accepts as the theoretical basis of the philosophy of chemistry. The lecture was illustrated, and its chief interest centers in one of the experiments, which, as it would seem, gave a very different result from that obtained by M. Troost from a series of similar experiments, noticed on page 321 of vol. xvi, III, of this Journal. Into the space above the mercury of one barometer-tube chloral-hydrate was evaporated, while the similar space of a second tube was filled with the vapor of chloroform. Into both of these atmospheres crystallized potassic oxalate was then introduced. Very soon a depression of the mercury column indicated that the water of crystallization of the salt had evaporated into the dry vapor of chloroform, while the constancy of level in the first tube showed that into the vapor of chloral-hydrate no such evaporation had taken place. Hence the conclusion that the space above the mercury in the first tube was already saturated with free aqueous vapor, and therefore that chloral-hydrate must become disassociated when it evaporates. By a reference to loc. cit. the bearing of this experiment will be more plainly seen, and the contradiction presented will serve to enforce the lesson, there suggested, that exceptions to a law so well established as that of the equality of molecular volumes in the aëriform state ought always to be very closely scrutinized.

At the same time with the address of Professor Wurtz we have before us a similar address by Professor Bayer, the successor of Liebig at Munich, and one of the most distinguished representatives of the German School of Organic Chemistry. It was delivered before the Königl. Akademie der Wissenschaften on the occasion of the birthday of King Ludwig of Bavaria, and is reprinted, with no flattering comments, by Professor Kolbe in the December number of the Journal für prakt. Chemie. The nominal subject of the address was "Chemical Synthesis," and we should have expected that, before such an audience, the eminent chemist, who had so recently made the synthesis of indigo blue, would have dwelt on the philosophy of the method by which this great result had been obtained; and, certainly, the circumstances connected with the synthesis both of indigotine and of alizarine illustrate most strikingly the great value of even the conventional forms of a well grounded "working hypothesis" in guiding scientific investigation. But, so far from this, the address was, for the most part, another popular exposition of the same subject treated by Professor Wurtz, and it contains such grotesque fancies that we can scarcely credit that the words we read were actually addressed to a learned society, even if in open session. We read of systems of atoms branching like trees—as if they were objects of natural history; of the possibility that the molecules of the diamond are large enough to be seen with a microscope, and to be isolated by mechanical pulverizing; of the molecules of marsh-gas as attaining sufficient velocity to carry them beyond the sphere of the earth's attraction, and that the exhalations of our marshes may thus contribute to form those cometary masses in which the spectroscope has discovered the presence of carbon. It would seem as if the purpose of the address were to bring the molecular theory into disrepute by a "reductio ad absurdum;" and while we cannot but regret the rude manner in which Professor Bayer has been ridiculed in the reprint to which we have referred, the address certainly invites criticism, and shows how absurd a good "working hypothesis" may be made to appear if we insist on realizing its conventional and temporary forms. No partial truths will bear such treatment, and these two addresses seem to us worthy of notice in this place as pointing out very clearly the only legitimate use of theory which forms the basis of our modern chemical philosophy. J. P. C.

4. *Experimental determination of the velocity of Light;* by A. A. MICHELSON, U. S. N., Instructor in Physics and Chemistry in the United States Naval Academy.—In a former number of this Journal (May, 1878, p. 394) a brief description is given by Mr. Michelson of a new method for the experimental determination of the velocity of light. It is based upon the method of Foucault so modified, as there described, as to admit of the use of any distance between the mirrors, and a correspondingly increased displacement of the reflected image. This method has since been put to use by the describer. In his experiments the speed of the mirror was 130

turns per second, the radius of measurement from fifteen to thirty feet, and the distance between the mirrors 500 feet. The displacement varied from 0·3 inch to 0·63, or about twenty times that of Foucault. The mean of ten determinations for the velocity of light in air was 186,508 feet, the extremes being 184,500 and 188,820. The author expresses the hope of being able, under more favorable conditions, to obtain the true result within a few miles.—(*Amer. Assoc. Adv. Science, St. Louis meeting*, 1878.)

II. GEOLOGY AND MINERALOGY.

1. *Note on Mountain-making by the Contraction of the Earth's crust;* by J. D. DANA.—A method of reproducing on a small scale the folding and fracturing of strata has been contrived by Professor A. FAVRE, of Geneva (Nature, of Dec. 5, from La Nature). He employs a stretched sheet of caoutchouc, to which clay in thin layers has been made to adhere, and allows it gradually to contract to its natural condition. The figures of the results, which he has published, represent foldings, faultings and crushings that look much like some of the effects in the world of rocks.

Mr. H. F. Walling, of Cambridge, in a paper on the relation of adhesion to horizontal pressure in mountain dynamics, read before the American Association at St. Louis in August, 1878, and published recently, suggested, still earlier, essentially the same mode of experimenting.

There are two general facts with regard to *actual* mountain-making that are not in accordance with the results which the caoutchouc affords.

(1.) Contraction in the earth's crust from cooling must have gone on continuously through time, with local differences, especially between the continental and oceanic areas, but still continuously; and therefore the effects, if like those on the caoutchouc, should have occurred all along the ages over the globe. But the fact is, that mountain-making has occurred over the continents only after a very long, quiet interval in which there were no disturbances beyond those from gentle oscillations. Geology has found that, for North America, from the Atlantic south of New York to the Rocky Mountains, and as the facts now stand, to the Pacific, there was but one mountain-making epoch between the close of Archæan time and the beginning of the Triassic era; and that this occurred at or near the termination of Paleozoic time. Thus, for the larger part of the broad continent, at least *three-fourths* of all geological time after the Archæan—amounting to seventy-five millions of years, if the whole covered one hundred millions—passed without any mountain-making disturbance, the greatest of which there is evidence, being that which raised the Lower Silurian about Cincinnati and to the northeast and southwest. During all that long time the sedimentary deposits were slowly thickening over the underlying crust, and lay like the clay over the caoutchouc, but this supercrust was nowhere bent up into steep folds or bold wrinkles through the contraction in progress.

There was probably disturbance and mountain-making in the Green Mountain region after the close of the Lower Silurian; and it is possible that effects of the same disturbance will be found along the eastern part of the Appalachian region farther south. But, if so, the general truth remains the same; for the close of the Lower Silurian occurred about half way between the Archæan and the close of the Carboniferous, making the antecedent period of quiet, on the above estimate of time, nearly forty millions of years. Over the Rocky Mountain region it is not yet proved that any great disturbances occurred at either of these eras, the first in the Wahsatch and Uintah region taking place not before the close of the Cretaceous.

(2.) The folds often have all the steeper inclinations facing in one direction and the less steep in the opposite, showing that the results of the pressure were unlike in the two opposite directions. The well known facts in the Appalachians, as first announced by Professor Rogers, abundantly illustrate this, and, also, those in the Jura Mountains.

The results obtained with the contracting caoutchouc correspond in one respect with rock-flexures, and it is a point not always considered by those who speculate on mountain-making. In mountain regions the flexures in the earth's strata are not, with very rare exceptions, represented by like flexures in the contracting crust. The former are generally between one and twenty miles in span; and the earth's crust could not have been thin enough at the close of the Paleozoic, when the Appalachians were formed, to have made such narrow bendings.

2. *Notes on the Coral Reefs of the Island of Itaparica, Bahia, and of Parahyba do Norte;* by RICHARD RATHBUN.—In the American Naturalist for July, 1876, I gave a short description of the coral reef skirting the outer shore of the island of Itaparica, in the bay of Bahia, Brazil. From a further examination of the reef and a study of the specimens procured from it, I am able to add a few items of interest to those previously given. I also wish to call attention to the existence of another reef, similar to that of Itaparica, to the south of the entrance to the Rio Parahyba do Norte. It was explored by Mr. John Branner of the Geological Commission. In shape and structure, as well as in the paucity of coral life upon it, this last agrees very closely with the Itaparica reef. It follows the trend of the shore, at a short distance from it, and between the reef and the shore there is an average depth of water of about six or seven feet only. The upper and outer portions of the reef are very irregular, but the inner part is comparatively smooth. No large corals are living upon it; at the northern end were collected a few small specimens of Porites, and toward the south a few Millepores, Symphyllia (?), and Porites. Much of the bottom surrounding the reef is very rich in coral growth. No sections were obtained giving us a clue to its

structure, which is, however, probably the same as that of the Itaparica reef.

In my former description of the Itaparica reef I stated that, while the lower portion was plainly made up in large part of true corals, the upper part appeared to contain only nullipores. I have since found that the worm tubes covering the surface of the reef enter very largely into its structure, probably to as great an extent as the nullipores, and give rise to an exceedingly hard, calcareous rock from which, ultimately, all traces of the worm-tube structure disappear. The worm-tubes and nullipores evidently compose the entire upper half of the reef. The nullipores, in the upper portions, so far as my observations went, were all of the encrusting lichen kind, and resulted in a compact structure, showing a sort of wavy lamination which is due to the successive growths of nullipores. The large digitate nullipores, so common at Pernambuco and at many places in the Bay of Bahia, are limited to the lower part of the reef, where they are associated with the true corals. At present nullipores are living in abundance only on the outer side of the reef, to a height of about one foot above medium low tide. Above the line of nullipores we find the entire upper surface of the reef coated with a layer of living worm tubes and large barnacles. The latter are generally broken off by the waves when dead, but the former remain, producing a loose structure near the surface, which becomes more compact below. The existence of nullipores in this upper portion indicates, however, that they lived on top of the reef at no distant time, and probably also that the reef has been elevated to a slight extent since then.

Within the reef the water is very shallow, being deepest near the reef and especially at and around the openings through it; it gradually shallows inward toward the beach. The bottom of this shallow inner channel is covered with sand and fragments of all sizes of corals and shells. Corals were not found in an upright position in this channel, nor do living corals exist there at all. The coral fragments are all old, frequently much worn, and almost invariably covered with nullipore and bryozoan growths, also dead. They form beds of considerable thickness in places, often more or less consolidated, and are dug up to burn for lime. The species discovered among the fragments are all found living in various parts of the bay, excepting *Mussa Harttii*, which does not apparently live at present anywhere in the Bay of Bahia. This extensive accumulation of broken corals, which must have been formed by the breaking off and heaping up of living corals from the surface of the reef by the breakers, when the reef was at a lower level, testifies to the exceeding richness of the coral life at that time. Corals have apparently ceased to be reef-builders in the Bay of Bahia.

3. *Semi-metamorphic fossiliferous rocks containing Serpentine.*—Dr. J. W. Dawson mentions facts on this subject from which the following are cited.

On the Saguenay River, at Lake Chebogamong, there is a band of serpentine associated with limestone; and Mr. Richardson obtained there a fossil tabulate coral which has part of its cells filled with serpentine, and also veins of serpentine intersecting it. The species is *Astrocerium pyriforme*, a species very common in the Upper Silurian limestones of the region in which it occurs, and characteristic especially of the Niagara formation. The formation containing the serpentine and limestone "is described as consisting of chloritic slates, in some places with hornblende crystals, dolomites, and hard jaspery argillaceous rocks."

At Melbourne, in the province of Quebec, rocks, referred by Logan to the Quebec group, pass upward into a thick series of hydromica schists, associated with quartzose bands and lenticular layers of crinoidal limestone. Over these, according to Logan, lies serpentine in thick beds (undoubtedly bedded rocks and not "eruptive") with other hydromica schists, limestone breccia, arenaceous beds, beds of anorthite, steatite, dolomite and red slates. The serpentine in the line of strike passes into dolomite and red slate. Fossils occur in the limestone interstratified with the serpentine, and also disseminated serpentine. The fossils are "*crinoidal* joints, fragments apparently of *Stenopora*," and tubular bodies which may be portions of *Hyolithes* or *Theca*, having an interior of calcite and a coating of serpentine. The cells of the fossils are sometimes filled with the serpentine; and the crinoidal joints are surrounded by it, with dolomite within.

Slices of these specimens, and those of other localities, were made by Mr. Weston when under the direction of the late Sir W. E. Logan. The other localities include Stamford, Farnham, Cleveland, Bedford, Oxford, Athabaska, Point Levi, Rivière du Loup, in most of which Lower Silurian fossils occur associated with hydrous silicates.

A locality at Pole Hill, in New Brunswick, discovered by Mr. C. Robb, has afforded specimens consisting of "fragments of crinoids and shells finely injected with an olive-green hydrous silicate of alumina, iron and magnesia. In one shell, apparently an *Orthoceras* or *Theca*, the dark green filling has cracked in the manner of Septaria [as often true of crinoidal stems in the Subcarboniferous of the Mississippi valley] and the fissures have been filled with carbonate of lime.

4. *The Physical History of the Triassic Formation of New Jersey and the Connecticut Valley*; by I. C. Russell (Ann. N. Y. Acad. Sci., i, 220–254).—The author, after giving some account of the Triassic formation of New Jersey and the Connecticut Valley, discusses the origin of the westward dip of the former and eastward of the latter. He adopts the hypothesis, suggested by Professor Kerr for the Trias of North Carolina, and by Professor F. H. Bradley for the regions of which Mr. Russell treats, that the New Jersey and Connecticut beds are opposite parts of an anticlinal. He holds also that the sandstone was once continuous over the whole intermediate region. The view is sustained on the ground

that the dip of the sandstone is in opposite directions in the two areas—10° to 15° northwestward in New Jersey, 5° to 50° [averaging 15°] to the eastward and southeastward in the Connecticut Valley; and on the view of a conglomerate on the western border of the former and eastern of the latter, whence it is inferred that here were the coast lines of the great estuary. Calculations from the dip give him for the thickness of the sandstone 25,000 feet, the consideration of faults in the beds being rejected by the author as without "plausible" support.

The hypothesis has objections, some of which, as they appear to the writer, are here stated.

(1) A thickness of 25,000 feet of water-made sandstone over an area of metamorphic rocks more than 100 miles in width, large portions of which are now several hundred feet above the sea-level, implies a subsidence of this region of over 25,000 feet, during the formation of the sandstone, or else, this depth of water.

(2) It implies also an elevation of the whole region—100 miles wide between the eastern and western limits—not only to this amount, 25,000 feet, but enough higher to give the average pitch of 15° eastward in the eastern sandstone and 10° to 15° in the western. For a width in the Connecticut Valley of fifteen miles (the area averages twenty), the dip produced by the alleged uplifting if only 14°—supposing no faults—would put the *western side of the Connecticut Valley* 20,000 *feet above its eastern;* and the site of New York City, on the eastern 15,000 or 20,000 feet above its present level, with 25,000 feet of sandstone over it. How much higher such an elevation would place the central portion of the region between the Connecticut Valley and New Jersey, the reader can calculate. Mountains on the globe at the present day are small in comparison.

(3) The hypothesis asks for an incredible amount of denudation; crystalline rocks of great depth as well as sandstone, over an area more than fifty miles wide having to be removed, and the surface brought down to its present level.

(4) The southern limit of the Connecticut Valley sandstone area is *north of the northern* limit of the New Jersey. The New Jersey area cannot, therefore, be on the opposite margin of the sandstone region to that of the Connecticut Valley. That there should have been an opposite side to the Connecticut Valley anticlinal, the New Jersey Trias should have extended up the Hudson River to Albany, N. Y., 120 miles north of its most northern point, Albany being in the same latitude with its northern limit in the Connecticut Valley; and hence the whole of western Massachusetts as well as of Connecticut, and all of Eastern New York, south of Albany, including the Green Mountain region, must have been raised to the enormous altitude referred to; and, besides, the sandstone must have since been removed from the whole so that no trace was left, with the exception of the Southbury basin. Further, the opposite side of the New Jersey part of the arch must have been somewhere out in the Atlantic south of

Long Island; and this island must have participated in the upward bend.

It is however to be admitted that, with the suggested method of accounting for the dip in the Connecticut Valley sandstone, there was no need of any sandstone in the Hudson River Valley; and, no need, in fact, of any sandstone over the intermediate region of crystalline rocks between that valley and the New Jersey area.

(5) No evidence of such an anticlinal, or of the supposed amount of erosion, exists excepting this—that the sandstone of the Connecticut Valley dips eastward, and that of New Jersey, situated wholly to the south of the southern limit of the Connecticut Valley area, dips northwestward, at the angles stated.

The existence of a conglomerate along the eastern border of the Connecticut area can be accounted for on the usual view—that this area in Triassico-Jurassic times was a Connecticut Valley estuary, at the termination of the Connecticut River, and had its violent floods, which may have been for part of the time enlarged by the waters and ice of a semi-glacial era—quite as well as by that of its being the eastern part of a much larger estuary; and even better.

The features of the Connecticut Valley beds afford other arguments; but it is not necessary to bring them up at this time.

J. D. D.

5. *Geological Survey of Pennsylvania.*—The following volumes containing Reports of Progress of this survey, have been recently issued, in addition to that by Mr. C. A. **Ashburner** mentioned on a former page of this volume. They show great activity in the Survey.

I. *Report of Progress of Bradford and Tioga Counties* (G), 272 pp. 8vo, with maps and sections; including: 1. on the Limits of the Catskill and Chemung formations, by A. **Sherwood**; 2. Descriptions of Coal fields, by F. **Platt**; and 3, on the Coking of Bituminous Coal, by J. **Fulton**.

II. *Report of Progress in Indiana County* (HHH), by W. G. **Platt**, 316 pp. 8vo, with a colored map of the County. 1878.

III. *Catalogue of the Geological Museum*, Part I, Rock specimens. 218 pp. 8vo. 1878.

IV. *The Brown Hematite Deposits of the Siluro-Cambrian limestones of Lehigh County, lying between Shimersville, Millerstown, Schnecksville, Ballietsville, and the Lehigh River* (DD), by **Frederick Prime**, Jr.; 100 pp. 8vo, with 5 map-sheets and 5 plates. 1878.—Professor Prime, shows that the rocks of the region, above the Laurentian, are, in succession, (1) the Potsdam sandstone; (2) a Siluro-Cambrian magnesian limestone, which has afforded Chazy fossils, besides an Orthoceras and Lingulæ too imperfect for determination; (3) Damourite (Hydromica) slates, all in general conformable; also (4) the Trenton limestone, as a direct continuation of the magnesian limestone, the beds affording encrinital stems identical with those found in Northampton

County overlying characteristic Trenton fossils; and (5) Hudson River slates, also conformably continuous with the preceding. Professor Prime treats also of the origin of limonite beds associated with the damourite slates, and of other points in the geology of the region. His method of determining the age of the crystalline schists by means of the fossils in the conformably associated strata gives positive results.

V. *Special Report on the Trap-Dykes and Azoic Rocks of Southeastern Pennsylvania* (E), by T. STERRY HUNT. Part I. Historical Introduction. 254 pp. 8vo. 1878.—This Historical Introduction is a general exposition and re-statement of the author's views on the "Azoic," Cambrian and Silurian rocks, of this and other countries, and the application of lithology to classifying and fixing the age of the various crystalline rocks, besides notes on eruptive rocks, along with a historical account of former views on these and other subjects, and a statement of the observations from various sources that appear to favor the views set forth. It is valuable as a definite exhibition of the present state of such views in the science, and of the arguments—not always just to the observations of others—by which they are sustained. The progress of the science will show how much of truth there is in them.

J. D. D.

6. *Report of the Geological Survey of Ohio.* Vol. III, *Geology and Palæontology.* Part I, *Geology.* 954 pp. 8vo.—This large volume consists, after its Preface by Professor J. S. NEWBERRY, the head of the Survey, of a Review of the Geological Structure of Ohio by Professor Newberry, and chapters on the Geology of different counties by the same, and the Assistant Geologists, Messrs. J. J. STEVENSON, M. C. READ, A. W. WHEAT, EDWARD ORTON, JOHN HUSSEY, F. C. HILL, A. C. LINDEMUTH, J. T. HODGE and H. HERZER, with supplemental Reports by E. B. ANDREWS and E. ORTON.

From Professor Newberry's Review we take the following conclusions.

The Cincinnati group does *not* represent the Hudson River group of New York, but the whole Trenton series, including the Trenton limestone and Hudson River group.

Many fossils of the Oriskany sandstone in Canada West, as *Spirifera arenosa*, *S. arrecta*, *Rensellaeria ovoides*, and *Avicula arenosa* are found mingled with *Favosites Gothlandica*, *Zaphrentis prolifica*, *Conocardium trigonale*, *Platyceras nodosum*, and many other well known fossils of the Corniferous limestone, which facts, in addition to the entire absence of Upper Silurian species, prove the Oriskany to be much more closely allied to the Devonian than to the Silurian.

The "Black shale" or "Huron shale" of the Devonian is made up of the black shales of the Lower Portage and the Genesee. In the shale, besides the gigantic *Dinichthys*, the jaw of a large Placoderm has been obtained which has been referred to a new genus, *Diplognathus*, also a new species of *Dinichthys*, a new *Ctenacanthus*, and several of *Cladodus*.

The volume contains much of great value to the science that would be here cited but for the limited space.

7. *Journal of a Tour in Marocco and the Great Atlas;* by Sir JOSEPH DALTON HOOKER, President R.S., etc., and JOHN BALL, F.R.S.;—*with an Appendix including a sketch of the Geology of Marocco;* by GEORGE MAW, F.G.S., etc. 499 pp. 8vo. London: 1878. (Macmillan & Co.).—This volume contains an account of a journey made by Sir Joseph Hooker, Mr. Ball and Mr. Maw in 1871 to a region which, as the preface remarks, was then little better known to geographers than it was in the time of Strabo and Pliny. The general account of the journey, occupying the first 348 pages, contains, besides incidents by the way, much information on the features, vegetation, and people of the country. It is followed by Appendixes on the Geography of the region, by John Ball; on its economic plants, a comparison between the Flora of the Canary Islands and of Marocco, and between that of Tropical Africa and of Marocco, by J. D. Hooker; on the Mountain Flora of two valleys of the Great Atlas, by J. Ball; on the Geology of the plain of Marocco and the Great Atlas, by George Maw.

The geological chapter contains much on the glacier phenomena of the Atlas region. "Unquestionable moraines" were observed in the province of Reraya, at a height of 6,000 feet, where was a "gigantic ridge of porphyry blocks," "with no admixture of small fragments," 800 to 900 feet in vertical height, damming up the deep ravine. The beds of bowlders flanking the northern escarpment of the Atlas plateau spread downward in great mounds and undulating ridges from a height of 3,900 feet to the borders of the plain 1,900 feet above the sea; and the moraines, commencing at a height of 5,800 feet, stretch up the Atlas ridge to a height of between 7,000 and 8,000 feet. Behind the moraines, at 6,200 feet, there was observed a plain of shingle, which seemed to be the bed of a small lake. At present there is not even perpetual snow on any part of the Atlas range. Since the era of the glaciers, the coast line has been raised at least seventy feet, as indicated by raised beaches at Mogador "which may possibly be cotemporaneous with raised beaches on the coasts of Spain and Portugal." A slight subsidence of the coast-line is stated to be now going on.

8. *Annual Report of the State Geologist of New Jersey, for* 1878. 132 pp. 8vo.—The prominent feature of this Report is a chapter on the "Glacial and Modified Drift" of the State, which is illustrated by a large map, showing the surface covered by the drift, the course of the "terminal moraine," and the "Oak Lands" and "Pine Lands." It treats also of the soils of the State, clays and their compositions, clay deposits, glass sand, progress of the topographical survey of the State, and gives analyses of some iron ores and limestones.

9. *Geological Record for* 1876; *an account of works on Geology, Mineralogy, and Palæontology, published during the year; with supplements for* 1874 *and* 1875. Edited by WM. WHITAKER, B.A., F.G.S., of the Geological Survey of England.

415 pp. 8vo. London, 1878. (Taylor & Francis.)—The third volume of the Geological Record is fully up to its predecessors in scope and thoroughness. The value of the work, to all engaged in the sciences included, would seem to be so obvious that it is a matter of surprise and regret that the editor should be compelled to call for more subscribers to insure its continued success.

10. *The Study of Rocks; An Elementary text-book of Petrology;* by FRANK RUTLEY, F.G.S., of the Geological Survey. 319 pp. 12mo. London: 1879. (Longmans, Green & Co.).—The study of rocks by the microscope is now recognized as so important a part of lithology and so universally employed, that an English text-book giving the methods employed cannot fail to be appreciated. The work is about equally divided between the description of methods of making thin sections and of examining them in the microscope, the description of the rock-making minerals, and of the rocks themselves. Mr. Rutley's work is a convenient one for the student. It is not, however, free from errors; the description and figure on page 94 show that the mineral referred to must be *microcline* and not orthoclase.

11. *Ueber die Zusammensetzung der Lithionglimmer*, von C. F. RAMMELSBERG.—Professor Rammelsberg has made a new examination of the lithia mica, lepidolite, with special reference to the amount of alkalies present. He finds that many of the previous analyses are incorrect in the determination of the lithia, and in this respect he rejects the analyses of Berwerth upon which Tschermak based his recent conclusions as to the chemical formula (this Journal, III, xvii, 176). For the lepidolite of Paris, Me., and Rozena, Rammelsberg writes the formula $\overset{\text{I}}{\text{R}}_2\text{AlSi}_3\text{O}_{10}$.—(*Ber. Ak. Berlin*, Oct. 28, 1878.) E. S. D.

12. *On the composition of Spodumene and Petalite;* by C. DOELTER.—Dr. Doelter has recently analyzed spodumene from Norwich, Mass., (1) and from Brazil (2) with the following results:—

	SiO_2	AlO_3	FeO	CaO	MgO	Li_2O	Na_2O	K_2O
(1)	63·79	27·03	0·39	0·73	0·21	7·04	1·10	0·12=100·41
(2)	63.34	27·66	1·15	0·69	...	7·09	0·98	.. =100·91

After making allowance for impurities, he obtains for the quantivalent ratio of $\overset{\text{I}}{\text{R}}:\text{Al}:\text{Si}=1:3:8$ (instead of 1 : 4 : 10 previously accepted) and writes the formula $\overset{\text{I}}{\text{R}}_2\text{AlSi}_4\text{O}_{12}$, where $\overset{\text{I}}{\text{R}}=\text{Li}$ and Na in the ratio of 15 : 1.

The composition of petalite is also discussed and the conclusion reached that is expressed by the formula $\overset{\text{I}}{\text{R}}_2\text{AlSi}_{10}\text{O}_{24}$, and the opinion is advanced that petalite bears the same relation in composition to spodumene that albite does to anorthite. E. S. D.

13. *Cacoxenite from Lake Superior.* (Communicated).—Mr. E. CLAASSEN of Cleveland has identified cacoxenite on the martite of Lake Superior. It appears in brownish-yellow acicular crystals forming radiating tufts.

14. *A titaniferous Chrysolite.*—M. DAMOUR has described a titaniferous chrysolite from Zermatt, Switzerland. It has a red color, similar to that of almandine garnet; G.=3·27. An analysis afforded SiO_2 36·14, TiO_2 6·10, MgO 48·31, FeO 6·89, MnO 0·19, ign. 2·23=99·86; this gives almost exactly the required ratio of 1 : 1 for bases to silicon.—(*Bull. Soc. Min. France*, ii, 15.)

15. *On the crystalline system of Pyrostilpnite* (*Fireblende*).—STRENG, in a paper devoted to a thorough crystallographic description of some silver minerals from Chañarcillo, Chili, states that pyrostilpnite (feuerblende) belongs to the orthorhombic, not the monoclinic, system. The conclusion is based both upon the meassured angles and the optical character.—(*Jahrb. Min.*, 1878, 897).

16. *Die Meteoritensammlung der Universität Göttingen*, von C. KLEIN.—The collection of meteorites at Göttingen, according to the recent catalogue of Professor Klein, is one of the great collections of the world, including meteoric stones from 115 distinct falls, and 90 meteoric irons from different localities.

17. *Enstatite rock from South Africa.*—Professor Maskelyne has described a rock from two localities in the Transvaal, South Africa, consisting solely of massive enstatite. This is a kind previously not recognized in lithology, although rocks have been known which, as lherzolyte, contain enstatite as a prominent ingredient.

III. BOTANY AND ZOOLOGY.

1. *Polyembryony, true and false, and its relation to Parthenogenesis.*—Strasburger has an interesting paper, *Ueber Polyembryonie*, in the Zeitschrift für Naturwissenschaft of Jena (1878), which we know as yet only at second hand, chiefly from a notice in the Archives des Sciences Phys. et Nat. of February, 1879.

Strasburger's researches upon the fecundation of the angiospermous Phænogams show that the embryo-sac very seldom produces more than one embryonal vesicle which is fecundated or capable of being fecundated. The single constant exception to this rule, known to him, is that of *Santalum album* which produces two; and one or two Orchids are mentioned in which the embryonal vesicle divides into two, occasionally. True polyembryony must therefore be very rare in Angiosperms. But seeds containing more than one embryo are of common occurrence in oranges, in *Funkia*, *Allium* or *Nothoscordum*, etc. According to Strasburger, all supernumerary embryos in such cases are adventitious, originate outside of the embryo-sac by a kind of prolification in the nucleus, and are not fecundated at all. They appear in the form of minute cellular protuberances, which lengthen by degrees and push into the embryo-sac by a sort of hernia, or pierce their way into it, becoming in the ripe seed veritable embryos, which it is not easy to distinguish from the one resulting from the fecundation of the embryonal vesicle itself. Independent as these adventive embryos are of fecundation, yet Strasburger could not obtain them in *Nothoscordum* when he had extirpated the stamens before anthesis and prevented access of pollen. But it appears that *Cœlobogyne* is just a case of this kind, namely, one in which an adventive embryo is habitually produced, instead of the normal embryo which fails from the want of fecundation, the male plant not being in cultivation. It is understood that this is not a mere inference, but that Strasburger has traced the development of the embryonal vesicle in the ovule of *Cœlobogyne*, followed by its failure and resorption, and by the independent production of adventive embryos in the manner above described.

This, then, gives an explanation of the long-disputed *parthenogenesis* of *Cœlobogyne*, and therefore of the less notable instances.

Parthenogenesis, it is then concluded, is only in appearance; it is sometimes, and perhaps in all cases, "a prolification of the nucleus." Now we should insist that, since the result is "a veritable embryo" (equivalent in structure, position of radicle, and ultimate growth to the true embryo), and not a bud, parthenogenesis is the just name; that the very interesting and important conclusion attained is that parthenogeny results, not from the development of an unfecundated embryonal vesicle, as was supposed, but from a development of other and extraneous cells into an embryo; also that it is not very rare, since the adventive or supernumerary embryos of various seeds are cases of this par thenogeny.

Not the least interesting consideration is, that we have here a counterpart of what De Bary terms *Apogamy*,—instead of an analogue of it. *Apogamy* is a vegetative prolification from what should normally result in the product of sexual reproduction. *Parthenogeny* proves to be the inverse of this, a vegetative production in the ovule of the proper result of sexual reproduction, viz: embryo. And finally, we have in these two modes taken together—what was quite to be expected—a manifest and significant narrowing of the *hiatus* between vegetative and sexual reproduction, which Mr. Darwin may turn to account.

Some applications of this new knowledge may be made. It is quite possible that more embryos than we are aware of may be adventive. Rather more than a year ago we gave an abstract in this Journal* of Mr. Francis Parkman's interesting paper on the hybridization of Lilies. It may be remembered that the greater part of his hybrids exactly reproduced the female parent. The explanation which we suggested to him, and which he refers to in his paper, was, that those plants were not really hybrids at all, but were from embryos originated without male influence. What then seemed to us the least improbable explanation, would now appear to be the one altogether probable. A. G.

2. *Notes on Euphorbiaceæ.* By George Bentham. (Extr. Jour. Linn. Society, No. 100, Dec., 1878, vol. xvii. pp. 185–267).—This thoughtful essay presents the general views attained to by Mr. Bentham on working up the genera of the great order *Euphorbiaceæ* for the ensuing volume of the Genera Plantarum. We need

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* The number for February, 1878, p. 151.

not specify any of the results, except to indicate the author's decision in the case of the *Buxeæ*. He does not follow his predecessors, Baillon and J. Mueller, who, much as they differ in other respects, agreed in setting up the order *Buxaceæ*, taking their cue from Agardh, and making much of the dorsal rhaphe. Bentham concludes that this small group, however well defined, ought not in a general view to be regarded as of higher grade than one of the primary divisions, or tribes, of *Euphorbiaceæ*. We are not the less pleased with this that we quite expected it.

A wider interest will be felt in Mr. Bentham's *excursus* on nomenclature, or rather on some questions which the study of *Euphorbiaceæ* brought up, and which some recent discussions have made pertinent. The general laws of nomenclature of our day, and the principles on which they rest, are laid down in the code which was reported by Alphonse DeCandolle to the Paris International Convention, in the year 1867, and, being approved, was published with a commentary in the autumn of that year, and in an English translation early in the following year. The laws, without the commentary, were printed in this Journal for July, 1868. The ten years succeeding have tested, somewhat thoroughly, the questions (nearly all of minor moment) upon which differing usages prevailed; and though one or two points are still mooted, the great majority of phænogamous botanists are coming to be of one mind and practice. But, as Mr. Bentham remarks: "The result has not been quite effectual in checking the ever-increasing spread of confusion in synonymy. Besides the young liberal-minded botanists who scorn to submit to any rule but their own, there are others who differ materially in their interpretation of some of the laws, or who do not perceive that in following too strictly their letter instead of their spirit, they are only adding needlessly to the general disorder. In the application as well as in the interpretation of these rules they do not sufficiently bear in mind two general principles; first, that the object of the Linnæan nomenclature is the ready identification of species, genera, or other groups for study or reference, not the glorification of botanists; and secondly, that changing an established name is very different from giving a new name to a new plant."

It is to the latter point that this most experienced and even-minded botanist addresses himself. "The rule that long-established custom amounts to prescription, and may justify the maintenance of names which form exceptions to those laws which should be strictly adhered to in naming new plants, is unfortunately now frequently ignored. . . . . The law of priority is an excellent one; and when a genus or species has been well defined by an early botanist in a generally accessible work, but has subsequently been neglected, and the plant became known under other names, it is well that the original one should be restored. . . . . On the other hand, it creates nothing but confusion to suppress a generic name, well-characterized and universally adopted by long custom, in favor of a long-forgotten one, vaguely designated in an obscure work, out of the reach of the great majority of botanists. . . . . The greater number of Necker's genera have been so imperfectly characterized, with so absurd a terminology, that they are quite indeterminable; and his names deserve to be absolutely ignored, except in the very few cases where Jussieu or other early French botanists have succeeded in identifying them, and corrected their characters; but even then it is doubtful whether these names should not bear the date of the correction, rather than of the original work. Adanson's "Famillès," with all the inconveniences of its form and absurd orthography, is much more scientific, and many of his genera are well defined, and have therefore been properly adopted." . . . .

Let us here interject a practical application. There is an old and well-established genus *Smilacina* of Desfontaines. There is a much older genus *Tovaria* of Ruiz and Pavon, founded in 1794, ever since accepted, and without a synonym. Recently Mr. Baker of Kew, finding that Necker has a *Tovaria*, published in 1790, and therefore four years earlier than that of Ruiz and Pavon, takes up this name in place of *Smilacina*, and leaves a new name to be made for the long-established homonymous genus. It will be said that the rule of priority demands the sacrifice, and that the identification of Necker's genus is sure, because the three Linnæan species of *Convallaria* which properly constitute Desfontaines' *Smilacina* are referred to it by name; and that, though it be a case of *summum jus summa injuria*, the injurious consequence is a necessity. But Mr. Bentham's characterization of Necker's work applies even to this instance. Twice over Necker's *Tovaria* is described as having a perianth of five sepals, and the berry is said to be one-celled. Desfontaines' *Smilacina*, on the other hand, is correctly characterized. Moreover, if we do not include this among those names of Necker which, Mr. Bentham says, "deserve to be absolutely ignored," we may yet find that the law of priority has another claim on it. In 1763 a much better botanist than Necker, viz: Adanson, founded a genus *Tovara* (essentially the same name as *Tovaria*) on *Polygonum Virginianum* L., which is not unlikely to be taken up as a genus; and the name would supersede Necker's by the same rule that Necker's supersedes Desfontaines' *Smilacina*. All things considered, then, this is a case for the application of the homely but useful rule *Quieta non movere*; and much of Mr. Bentham's pertinent advice may be condensed into this maxim. But there remain nice questions to settle with regard to the names and extent of the liliaceous genus.

"The representing the Greek aspirate by an *h* was generally neglected by early botanists; but now, ever since DeCandolle altered *Elichrysum* into *Helichrysum*, modern purists have insisted upon inserting the *h* in all cases; and this has been so far acquiesced in that it is difficult now to object to it, though it has the effect of removing so many generic names to a distant part of all indexes, alphabetical catalogues, etc. Admitting the propriety of adding the aspirate in new names, I had long declined to alter old names on this account; now, however, I find myself compelled to follow the current." Which is, on the whole, regretable, especially as Alph. DeCandolle would hold out with him. See the latter's comment on his Article 66, in which the remark is dropped that, "we do not see why we should be more rigorous than the Greeks themselves." Oddly enough, these same writers who must supply the aspirate to the *e* omit it from the *r*, and write *rachis* and *raphe*, instead of *rhachis* and *rhaphe*,—which is exasperating to lovers of uniformity.

It is unnecessary here to cite Mr. Bentham's appropriate illustration of the indivisibility of the two-worded name of a plant. The proper apprehension of this, and of the paramount rule that no *unnecessary* new names should be given to old plants, will go far to rid the science of a principal remaining ambiguity in nomenclature. For it clearly follows that when a plant has a rightful name under its proper genus, the specific half of it is not to be changed because of any earlier specific name under some other genus, to which the plant does not belong. A. G.

3. *Journal of a Tour in Marocco and the Great Atlas.* By JOSEPH DALTON HOOKER, K.C.S.I., etc., and JOHN BALL, F.R.S., etc. A brief notice of the geological appendix in this work is given on page 332. We add here a few words on the botanical results. Sir Joseph Hooker contributes an article on some of the economic plants; the most important portion of which relates to the Argan tree, the natural and economical history of which is now pretty well known. The narrative contains a wood-cut figure of a group of old Argan trees, in which goats are seen high up among the spreading branches, feeding upon the fruit. Of higher scientific interest is the comparison of the Canarian flora with the Maroccan (of which we cannot here undertake an abstract); also the comparison of the Atlas flora with that of the mountains of Grenada, and of northern Europe. So far as is yet known, the north European or Germanic character largely preponderates in it, yet absolutely without alpine representatives. These last probably exist, but at elevations which have not yet been reached. It was a trying experience to have surmounted a pass of the Great Atlas range, only to encounter a snow-storm, and to be obliged to turn back without reaching the higher crests so near at hand. Mr. Ball has worked up the botanical results technically and systematically in his *Spicilegium Floræ Maroccanæ*, which fills nearly 500 pages of the sixteenth volume of the Journal of the Linnean Society, and is illustrated by twenty plates. A. G.

4. *Eaton's Ferns of North America.*—We are not sure that we have noticed the later issues of this work, so important to all fern-people and botanists. But, in any case, we must make a note of Parts 12 and 13, a double number, which has just come to hand, the plates are so excellent. As to the letter-press, this is always satisfactory. *Aspidium acrostichoides* is well represented, and well colored. The same would be said of *Pteris aquilina*, were it not that the frond looks diminutive. The three *Asplenia* make a

fine plate. But the figure of *A. parvulum* is stiff: we never saw it growing bolt upright, and the difference in size between this and the other two is not made sufficiently manifest. A somewhat more northern range must be assigned to this species. We found it rather common in the mountains of the southern part of Virginia, as well as in North Carolina. *Adiantum Capillus-Veneris*, the subject of the next plate, and which is luxuriantly delineated, has just now come in from the same region in Virginia,—a discovery by Mr. Shriver. *A. emarginatum* would have been perfectly presented if the green were brighter and lucid. The three species of *Notholæna* make an admirable plate. A. G.

5. *Algæ Amer. Bor. Exsiccatæ;* by FARLOW, ANDERSON & EATON, *Fasc.* III.—The third Fasciculus of this distribution of North American Algæ has just been issued. It consists of only thirty specimens, covering twenty-nine species and one variety. But as most of the species are large plants, the paper used is of the folio size of most American herbariums. Twenty of the Algæ are of the black or olive-green series, and the other nine are Florideæ. Among the rarer kinds are *Sargassum pterpleuron*, from Florida, *Postelsia palmæformis*, *Pterygophora Californica*, *Dictyoneuron* and *Nereocystis*, from the Pacific Coast, and *Saccorhiza dermatodea*, from the coast of Maine. The Florideæ embrace several of the large *Gigartinas* of the Pacific shore, and three or four of those very puzzling forms of *Callophyllis*, which have so long been an unsolved riddle to the students of this class of plants. Dr. Farlow, who has done nearly all the work of identification, still hesitates to acknowledge the presence of the European *Callophyllis laciniata* on the coast of California; but then he has named two new species of the genus, No. 127, *C. furcata*, and No. 129, *C. gracilarioides*.

This is a very important publication, on account of the care, labor, expense, and critical investigation which are bestowed upon it, not to speak of the beauty and perfection of the specimens; and the associated authors should receive the best thanks of botanists. A. G.

6. *On the Black Mildew of Walls.*—Professor LEIDY remarked that in the number of "Hardwicke's Science Gossip" for August, presented this evening, there is an article by Professor Paley entitled, "Is the Blackness on St. Paul's merely the effect of Smoke?" According to the author, the blackness is mainly due to the growth of a hitherto undescribed lichen, which appears to flourish on limestone and in situations unaffected by the direct rays of the sun. Professor Leidy continued, that his attention had been called a number of years ago to a similar black appearance on the brick walls and granite work of houses in narrow shaded streets, especially in the vicinity of the Delaware River. Noticing a similar blackness on the bricks above the windows of a brewery, from which there was a constant escape of watery vapor, in a more central portion of the city, he was led to suspect that it was of a vegetable nature. On examination, the black

mildew proved to be an alga, closely allied to what he supposed to be the *Protococcus viridis*, which gives the bright green color to the trunks of trees, fences, and walls, mostly on the more shaded and northern side, everywhere in our vicinity. It probably may be the same plant in a different state, but, until proved to be so, may be distinguished by the name of *Protococcus lugubris*. It consists of minute round or oval cells, from 0·006 to 0·009^{mm} in diameter, isolated or in pairs or in groups of four, the result of division; or it occurs in short irregular chains of four or more cells up to a dozen, occasionally with a lateral offset of two or more cells. The cells by transmitted light appear of a brownish or olive-brownish hue. In mass to the naked eye the alga appears as an intensely black powder.—*Proc. Acad. Nat. Sci. Philad.*, Sept. 3, 1878.

7. *On two Bermuda fishes, mistakenly described as new;* by Dr. A. Günther.—In the February number of the Annals and Magazine of Natural History, pp. 150–151, is published a paper by Dr. A. Günther, F.R.S., "On two new Species of Fishes from the Bermudas." The species which he names *Gerres Jonesii*, was described by me in this Journal, vol. vii, August, 1874, p. 123, under the name *Diapterus Lefroyi;* that called by him *Belone Jonesii*, was also described by me, under the same name, and dedicated to the same worthy naturalist, in this Journal, vol. xiv, October, 1877, p. 295. The descriptions harmonize in all essential details, and I have myself seen the specimens which were subsequently presented by Mr. Jones to the British Museum, though my own descriptions were drawn up from other specimens collected by myself at nearly the same time and locality.

Smithsonian Institution, Feb. 17, 1879. G. BROWNE GOODE.

8. *Alaska Chitons and Limpets.*—A paper on this subject, by W. H. Dall, giving a synopsis of the genera and notes on the various species with their synonymy, makes a number of the Bulletin of the U. S. National Museum. It is illustrated by four plates, and some wood-cuts, representing the dentition of many of the species. The Bulletin is not yet separated into volumes, and this paper is No. 4 of Mr. Dall's "Scientific Results of the Exploration of Alaska," the first two numbers being in Proc. Philad. Acad., 1876.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *On the discovery of mineral wax, Ozocerite, in Utah;* by Professor J. S. Newberry. (From a letter to the Editors.)—I have obtained some of the recently discovered ozocerite in Salt Lake City from Professor J. E. Clayton, to whom also I am chiefly indebted for such information as I have in regard to its place and manner of occurrence. He writes me as follows: "The geographical position of the ozocerite deposits is in the Wahsatch Range, on the head waters of the Spanish Fork, east from the south end of Utah Lake. The material has been found saturating

beds of brown and bluish shales, probably of Tertiary age, and in masses of various dimensions more or less mingled with clay. These shales extend from the San Pete valley in a north-northeast direction for a distance of fifty or sixty miles, and the width of the area or basin which they occupy is at the middle point about twenty miles. The shale beds richest in paraffine vary in thickness from twenty to sixty feet, but there is no considerable accumulation of that substance on the surface, nor would this be possible, as it would be destroyed by the annual fires which sweep the country. I examined portions of this region two years ago for coal, and found in the oil shales a few thin seams, and saw the wax-like exudation in several places, but only in small quantity."

Other parties in Salt Lake informed me that the paraffine itself is sometimes twenty feet thick, and that the quantity is enormous; but Professor Clayton says that such statements are not authorized by any facts which have come under his observation.

In the above remarks I have called the earth wax of Utah ozocerite. As it has been stated to be zietrisikite, I may say that on my return from the west, my son and assistant, Spencer B. Newberry, made a series of careful experiments in my laboratory to determine its true nature, comparing it with the description of these hydrocarbons, and with authentic specimens which I have received directly from Galicia. He found that it had a melting point of 61·5° C., that it was completely soluble in a large volume of boiling ether, and that boiling alcohol extracted from it twenty per cent of a white, wax-like substance. It seems, therefore, to be certainly ozocerite and not zietrisikite; the latter melting at 90° C., and being insoluble in ether.

2. *The American Antiquarian: A Quarterly Journal* devoted to early American History, Ethnology and Archæology, edited by Rev. STEPHEN D. PEET. Cleveland, Ohio. (Brooks, Schinkel & Co.).—The third number of this new Journal was published in January, 1879; among other papers it contains one on native American Architecture, by E. A. Barber, which is illustrated by several figures of Colorado Cliff houses. The Journal is well edited and promises to be of value to all interested in Archæology.

3. *Wanderings in South America, the Northwest of the United States and the Antilles, in the years* 1812, 1816, 1820, 1824; by CHARLES WATERTON, Esq. New edition, edited with biographical introduction and explanatory index, by the Rev. B. G. Wood. 520 pp. 8vo. London, 1879. (Macmillan & Co.).—The volume of "Waterton's Wanderings" was first published in 1825, and since that time it has afforded pleasure and profit to a large number of readers. In the present edition the original account is left unaltered, but to this are added a full and appreciative biography of the author, by the Rev. B. G. Wood, and a valuable Explanatory Index, covering 150 pages, in which information is given in regard to the many unusual animals, birds and trees, mentioned in the body of the work.

4. *A Real Telegraph.*—A new invention of a really practical character, not a mere "paulo post futurum" invention like many we have heard of lately, has just been made by Mr. E. A. Cowper, the well-known mechanical engineer. It is a real telegraphic writing machine. The writer in London moves his pen, and simultaneously at Brighton another pen is moved, as though by a phantom hand, in precisely similar curves and motions. The writer writes in London, the ink marks in Brighton. We have seen this instrument at work, and its marvels are quite as startling as those of the telephone. The pen at the receiving end has all the appearance of being guided by a spirit hand. The apparatus is shortly to be made public before the Society of Telegraph Engineers.—*Nature*, Feb. 6.

5. *The chemical composition and physical properties of Steel Rails.*—Dr. C. B. DUDLEY, Chemist of the Pennsylvania Railroad Company, has made an extended investigation of the relation between the chemical composition of steel rails and their power to withstand wear, and in view of the great practical importance of the subject his results cannot fail to have a high value. Some of his conclusions are:—that high phosphorus is inconsistent with safety; that the silicon should be as low as is consistent with the successful working of the Bessemer process; that the best range of carbon is 0·25 to 0·35 per cent, and of manganese from 0·30 to 0·40 per cent. He also concludes that the wearing power of steel rails does necessarily increase with their greater hardness.—(*Trans. Inst. Min. Engineers*, vol. vii.)

6. *The Meteorologist*, published monthly in the interest of the Science of Meteorology. Vol. i, No. 1, March, 1879, J. M. L. STUMP, editor, Greensburg, Pa. An eight-page journal devoted to meteorology.

7. *The Paleontologist.* No. 3, Jan. 15, 1879, Cincinnati. Contains description of new species of fossils from the Lower and Upper Silurian rocks of Ohio, by U. P. James.

OBITUARY.

Professor GUSTAV LEONHARD, of Heidelberg, died December 27, 1878. He was well known as the author of works on Mineralogy and Geognosy, and as editor with Professer H. B. Geinitz, of the Neues Jahrbuch für Mineralogie, Geologie und Paleontologie.

On the extent and significance of the Wisconsin Kettle Moraine, by T. C. Chamberlain, A.M., State Geologist and Professor of Geology in Beloit College (Trans. Wisc. Academy of Sciences.)

On the Annelida Chætopoda of the Virginian Coast, by H. E. Webster (Transactions of the Albany Institute, vol. ix, January, 1879.)

Apuntes relativos à los Huracanes de las Antillas en Septiembre y Octubre de 1875 y 1876; Discurso leido en la real Academia de Ciencias Medicas, Fisicas y Naturales de la Habana en Sesion del 9 de Septiembre de 1877 y siguientes; par el socio de merito Rdo, P. Benito Viñes, S. J., Director del Observatorio. 25 pp. 8vo. Havana, 1878.

The Local Geology of Davenport, Iowa; by Rev. W. H. Barris (Davenport Academy Natural Sciences, Sept., 1876). New Fossils from the Corniferous Formation at Davenport (ibid., Oct., 1878).

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[THIRD SERIES.]

ART XLI.—*Experiments in Cross-Breeding Plants of the same variety;* by Professor W. J. BEAL.

EARLY in the spring of 1877, the writer received the first review of Darwin's book on "The Effects of Cross and Self-fertilization of Plants." The book seemed to be a most instructive production, one which has not been excelled in importance to the farmer by any work in this or in any age. But, in the words of the Gardener's Chronicle, "It is certain that these practical results will be a long time filtering into the minds of those who will eventually profit most by them." If the results are so valuable, and if it will take a long time to reach the farmers, this "filtering" process cannot begin too soon, nor be too continuously kept before them. The writer lost no time in trying similar experiments on several of our cultivated plants, as apples, onions, Indian corn and beans.

Experiments with Indian corn.—Yellow dent corn was obtained from two men in different portions of Michigan. In one case the corn had been kept ten years or more on the same farm, and in the other case fifteen years or more on the same farm. In both cases the corn was much alike. The two lots of corn were planted in alternate rows in a plot by itself. The tops of one set of rows were all cut off, thus securing a perfect cross on those stalks. Seed from this cross was saved and planted to compare with corn not so crossed. The yield from the crossed seed exceeded the yield of that not crossed, as one hundred and fifty-three (153) exceeds one hundred (100).

Crossing black wax beans.—There were, as shown in the plat below, eight short rows two feet apart with the plants finally thinned on July 10th, to five plants about fifteen inches apart in the row. The seed for half the rows (alternating) is called "old stock," and was raised in the garden the previous year from seeds which descended from those raised on the place for nine years or more.

The "crossed stock" was obtained as follows: in 1877, some seeds of the same variety of beans were purchased of James Vick. These were planted in a drill evenly mixed with seeds of the old stock. These grew and looked alike, but the flowers were inter-crossed by bees. Seeds of this crop are termed "crossed stock."

On May 31, 1878, fifteen seeds were planted in each of the eight rows. The plants from the crossed seeds were generally much the largest and as will be seen kept green the longest.

In ten days after planting, seeds of the old stock came up in each row as follows:...................... 4, 7, 7, 9=27
In ten days the crossed stock came as follows: 12, 10, 6, 11=39
In seventeen days the old stock came as follows: 7, 11, 10, 10=38
" " " crossed " " " 12, 13, 10, 14=49

On July 22, the pods fit for cooking on each plant numbered as follows. The pods on the two lots of plants were about alike in size.

Old stock	36	1	dead	7	13	= 57	
Crossed stock	dead	0	0	41	0	=	41
Old stock	0	0	8	0	11	= 19	
Crossed stock	6	22	34	0	17	=	79
Old stock	30	0	0	0	0	= 30	
Crossed stock	41	37	21	31	0	=	130
Old stock	0	0	0	0	2	= 2	
Crossed stock	16	29	30	26	2	=	103

Total old stock = 108
Total crossed stock = 353

This variety is greatly raised for the purpose of supplying an early crop of beans to eat pods and all while young. The difference will be seen to be over three to one in favor of the crossed stock.

On August 9, the pods fit for cooking or past that condition were as follows:

Old stock	52	60	dead	43	45	= 200	
Crossed stock	dead	24	16	51	83	=	174
Old stock	38	46	44	71	37	= 236	
Crossed stock	35	52	58	69	62	=	276
Old stock	39	34	30	47	87	= 237	
Crossed stock	63	48	11	66	61	=	249
Old stock	38	46	54	33	39	= 210	
Crossed stock	38	90	52	88	81	=	340

Total old stock = 883
Total crossed stock = 1048

On or before September 16, all were harvested. The pods on each plant numbered as follows:

Old stock	60	62	dead	45	39	=	206	
Crossed stock	dead	160	54	29	139	=		382
Old stock	45	48	36[*]	71	37	=	237	
Crossed stock	36	145	91	72	51	=		395
Old stock	45	35	37	38	35[†]	=	190	
Crossed stock	103	68	55	128	75	=		429
Old stock	30	39	48	28	40	=	185	
Crossed stock	136	159	58	172	128	=		653
			Total old stock			=	818	
			Total cross stock			=	1859	

On comparing the table for August 9th, with that for September 16, it will be seen that some plants of the old stock had lost part of their fruit. This was on account of the decay of 101 pods. The table also shows that two branches were broken and had died before maturing. These contained 73 pods.

Adding 101 and 73 to 818, we have 992 pods of the old, against 1859 of the crossed. In harvesting, all those pods badly damaged were rejected. The beans of the old stock weighed 29·77 ounces avoirdupois, those of the crossed stock weighed 70·33 ounces avoirdupois, or nearly in the proportion of 100 to 236.

The difference would be a little less, if we allow for the broken plants and decayed pods on the old stock. One plant of the old and one plant of the crossed stock died early and produced no fruit.

Six lots of 50 beans each, were taken at random from the old stock and weighed as follows:

50 seeds	281 grains.	50 seeds	260 grains.
50 seeds	262 grains.	50 seeds	259 grains.
50 seeds	270 grains.	50 seeds	284 grains.

Total, 1,616 grains. Average, 269⅓ grains.

The same number of seeds were taken from the crossed stock and weighed as follows:

50 seeds	220 grains.	50 seeds	210 grains.
50 seeds	219 grains.	50 seeds	210 grains.
50 seeds	200 grains.	50 seeds	220 grains.

Total, 1,279 grains. Average, 213⅙ grains.

The average weights of an equal number of beans from each stock were nearly as 100 to 79 in favor of the *old* stock.

Agricultural College, Lansing, Michigan.

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[*] This plant contained a dead branch with 21 immature pods.

[†] This plant contained a dead branch with 52 immature pods.

ART. XLII.—*On the Force of Effective Molecular Action;* by Professor W. A. NORTON.

[An abstract of this paper was read before the National Academy of Sciences, April 18, 1878.]

IN my paper on the variability of the ultimate molecule, published in the March number of this Journal, I gave the following theoretical expression for the force of effective action of one ultimate molecule of a body on another contiguous to it, deduced from certain fundamental conceptions which were succinctly stated:

$$F=\frac{n(3r^2+2rx)}{(r+x)^2(2r+x)^2}-\frac{m}{x^2}, \qquad (1)$$

in which x denotes the distance between the electric envelopes of the contiguous molecules; r the distance between the center of emanation of the attractive force, f, represented by the first term, and that of the repulsion f', represented by the second term; n the coefficient of the attraction f, and m that of the repulsion f'. The expression has been simplified by making one or two assumptions that do not strictly accord with fact, but which can occasion no material error in the general discussion now proposed; as will be shown on another occasion.

If we put $x=ur$, $\frac{n}{m}=k$, and $\frac{m}{r^2}=p$, it becomes

$$F=\left(\frac{k(3+2u)}{(1+u)^2(2+u)^2}-\frac{1}{u^2}\right)p. \qquad (2)$$

If this be a true theoretical expression for the force of effective molecular action, it should comprise the essential mechanical theory of solids, liquids, and gases, as well as the special mechanical features of individual substances; and should successfully withstand all the quantitative and qualitative tests that can be applied to it. I propose now to give the result of the application of a number of such tests; and to show that the characteristic features and laws of the three different states of aggregation are deducible from it.

Theory indicates that in the comparison of different solids, liquids, or gases, among themselves, at the same temperature, $p\left(=\frac{m}{r^2}\right)$ may be regarded as constant. In fact we shall for the present assume that both m and r, as well as p, are constant for substances in the same state of aggregation, when the temperature is the same. Upon this assumption one substance will differ from another, in its essential molecular condition, only in the value of k, that is of the ratio $\frac{n}{m}$ of the coefficients of the attractive and repulsive forces f and f'. I have made a series of calculations of the values of F for various assigned values of x, answering to a number of different values attributed to k. Each set of calculations, if graphically represented, will give a curve that may be termed a *curve of effective molecular action*. It will represent to the eye the essential mechanical features of a body for which the assumed value of k obtains.

1.

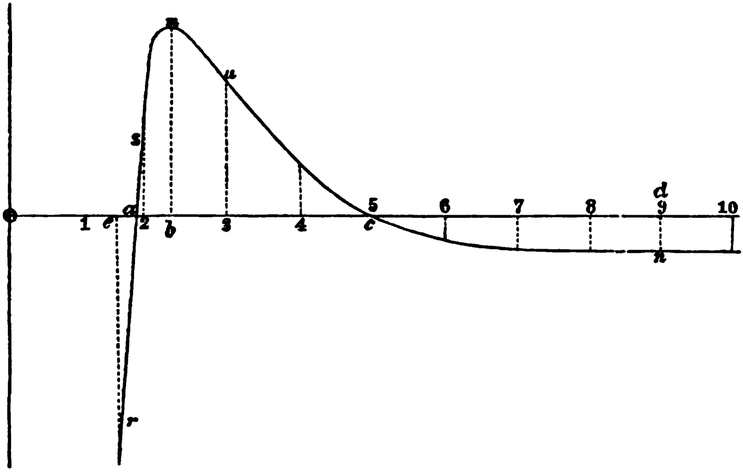
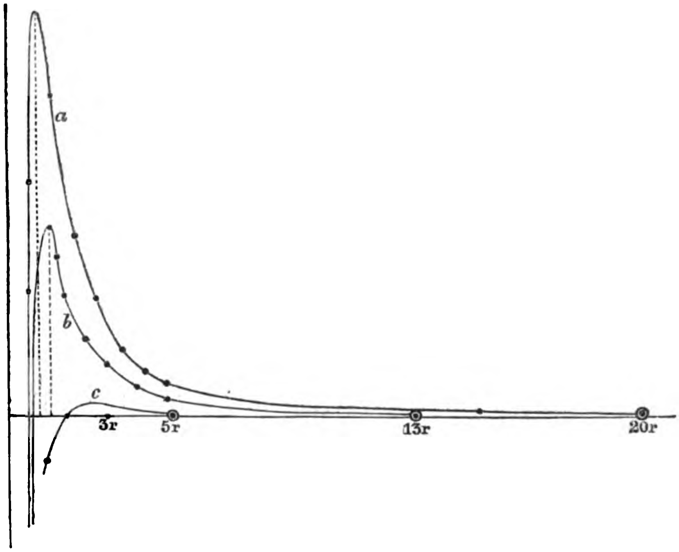


Fig. 1 is such a curve answering to $k = 5{\cdot}428$. In Fig. 2, curve c, the same curve is shown on a smaller scale (both horizontal and vertical). Curve a in this figure answers to $k = 12{\cdot}41$, and curve b answers to $k = 9{\cdot}44$. Fig. 1 may be taken as a type curve exhibiting the features common to the special curves. The positive ordinates indicate comparative values of an effective attractive force in multiples of p, answering to certain distances x expressed in multiples of r; and the negative ordinates indicate values of an effective repulsive force obtaining at other distances x. The distance Oa, between molecular envelopes, at which the effective force is zero, is that which obtains when no external force of stress is in operation. It may be called the *neutral distance*. At all less distances, x, as Oe, that may supervene when a compressive stress is applied to the body, the effective force, er, is repulsive. When a tensile stress is in operation, increasing the distance x, the effective force, as $2s$, becomes attractive, and increases in intensity to the maximum value bm, at the moment of rupture. At greater distances, as $O3$, the effective attraction falls off; and passes into a repulsion when the distance becomes greater than Oc. This repulsion increases with the distance to a maximum dn, and then diminishes continually to an indefinite distance. This effective repulsion, operating beyond the sphere of the effective attraction, manifests itself as a force of resistance in the contact of bodies. A glance at the curves, (*a*), (*b*), (*c*) in fig. 2, will show that the neutral distance, *Oa*, (see type curve, fig. 1), and the distance, *Ob*, answering to the maximum attractive ordinate, diminish, in multiples of r, as k increases; and that on the other hand, *Oc* and *Od* increase as k increases. The maximum attractive ordinate increases, in terms of p, as k increases, but the maximum repulsive ordinate augments as k diminishes.

2.



The special calculations I have made answer to various assumed values of the ratio k, ranging from 0 to 20. I find that when this ratio exceeds 4·934, the effective force will be attractive over a certain range of distance, and thus that a portion of the representative curve will lie above the axis x, as in the curves shown in fig. 2; and that when this ratio is less than 4·934, the effective action will be repulsive at all molecular distances, and therefore that the curve will lie wholly below the axis, x, as in fig. 3. We must, therefore, conclude that for all solids and liquids, k must exceed 4·934.

The absorption of the pulses of heat by the molecular envelopes of a body tends to expand these envelopes, and at the same time to augment the coefficient of repulsion, m. Heat, therefore, tends to diminish the ratio k, and so to depress the curve of effective molecular action. When by the continued access of heat, this ratio is brought to a certain small value somewhat greater than 4·934, the molecules are in general brought into a certain condition answering to the liquid state, and liquefaction ensues. When, by a still further rise of temperature k equals 4·934, the liquid has reached the boiling point in vacuo. The curve of effective molecular action is now that shown in fig. 3 for $k=4·93$, and the distance between the molecular envelopes, is 2·84 r.

All special curves, answering to particular solids or liquids, and so to values of k greater than 4·934, have certain common features, which should correspond to properties that have been recognized as belonging to all substances in the solid or liquid state. (1.) One of these is that the curves differ little from a right line at the neutral point a (fig. 1). This corresponds, graphically, to the well known law of molecular displacement, that the effective resistance developed is, for small displacements, porportional to the displacement. The ratio of the effective force $2s$, to the displacement $a2$, may be taken as the measure of the coefficient of elasticity, in considering the comparative values of this coefficient answering to varying amounts of tensile stress, and so to various degrees of molecular displacement. As it appears that this ratio is nearly constant, within small limits, the coefficient of elasticity as experimentally determined, should be nearly constant within such limits; which is a well-known general fact.

(2.) An examination of the curves will serve to show—what is a conspicuous result of the discussion of the equation—that as the tensile stress increases, the coefficient of elasticity as measured by the ratio just stated, should diminish slowly at first and then more rapidly. Experiment has established that in general the coefficient of elasticity of a material varies after this manner. But to make the test more decisive, I have made a series of detailed comparisons of the theoretical with experimental results. It appears that for all values of k ranging from 7·576 to 20 (which, as will hereafter appear, may be regarded as including all the more tenacious solids) the law of variation of the molecular ratio, $\frac{s2}{a2}$ (fig. 1); from the point a to m (i. e. from zero of stress to the point of rupture) is sensibly the same. Thus at the point m, answering to rupture, this ratio becomes reduced to 0·303 of its value at the neutral point, a, when $k=20$; to 0·301 when $k=12·41$; and to 0·316, when $k=7·576$; and the correspondence is equally close at points intermediate between a and m. I have computed the comparative values of the ratio $\frac{s2}{a2}$, for eighteen supposed values of the displacement, $a2$, and compared this scale of computed values,—which, as we have just seen, should answer to any of the more tenacious materials—with a corresponding series of experimental values of the coefficient of elasticity for bars of cast iron, wrought iron, steel and oak; with the following results. For a bar of cast iron, experimented on by Captain Rodman (U. S. Army), the correspondence is very close. The greatest ratio of error does not exceed $\frac{1}{12}$. For five bars of wrought iron taken for comparison, the correspondence proves tolerably close up to a stress equal to half the tenacity; but at the higher ratios of stress, the coefficient of elasticity diminishes much more rapidly than the theory calls for. For the cast steel bar taken, the coefficient of elasticity is greater than at the neutral point and materially greater than the corresponding molecular ratio, until near the point of rupture, where the two become nearly equal ($\frac{3}{10}$). Several bars of oak examined proved to be in the same category with the cast steel, except that the coefficient ratio at the point of rupture was reduced to from $\frac{6}{10}$ to $\frac{9}{10}$ instead of $\frac{3}{10}$. Four bars of blister steel examined present a case just the reverse of that of the cast steel bar; the coefficient ratios are at all stresses less than the corresponding molecular ratios. In the cases cited the correspondences between the theoretical and the experimental results are sufficient to lend support to the theory; but the discrepancies noticed can only be reconciled with it by admitting that some modifying causes are in operation which tend to produce abnormal deviations from the theoretical results obtained from our formula. Now, as a matter of fact, such modifying causes are known to exist. We have already seen that the ultimate molecule is variable both in its dimensions and its forces, under the operation of varying forces of stress; that k is liable to variation, and hence that the values of F' for the same values of x may change, and the molecular curve shift its position and rise or fall according as k increases under the stress or diminishes. As for the actual tendency of a tensile stress, it is immediately to draw the molecular envelopes farther away from their central atoms. It should thus enlarge the effective molecules, and so by increasing the distance between their centers tend to diminish the coefficient of elasticity. But the enlargement of the envelopes should also tend to alter the value of n; and it appears, on a careful investigation of the diverse possible mechanical conditions of the envelopes, that n may either be increased or diminished, and so the value of k become either greater or less. These incidental effects of forces of stress are adequate to the production of all the deviations, under consideration, from the normal molecular condition represented by the formula or by an unvarying curve; except the very large deviations noticed in the case of the wrought iron bars, when the stress amounted to a large fraction of the breaking weight, which may be reasonably ascribed to a flow of the molecules.

(3.) The distance *ab*, (fig. 1) between the neutral point and the point of rupture increases from 0·302*r* for $k=20$, to 0·60*r* for $k=5{\cdot}428$. This is about its maximum value. From this value of *k* to the ratio 4·934 it decreases from 0·60*r* to zero. Now *r* is the distance between the centers of attraction and repulsion, both of which lie within the molecular envelope. It is therefore a small fraction of the radius of the outer surface of the envelope, or outer surface of the effective molecule, and a much smaller fraction of the distance between the centers of contiguous molecules. We should then expect, on theoretical grounds, that when a bar suffers rupture under a tensile stress, the elongation would be a small fraction of its length. This is well known to be generally true for the more tenacious materials (e. g. the metals and different varieties of wood). India rubber is a striking exception. Its great extensibility is probably due to a great expansibility of its molecular envelopes, under a tensile stress. The unequal extensibility of different qualities of wrought iron, also finds its theoretical explanation in an unequal expansibility of molecular envelopes, with the attendant variations in the molecular curve.

(4.) The ordinates of the portion *ra* of the molecular curve represent the molecular resistance developed by a compressive stress. These increase (as they should do) without limit, as the distance *Oe* between the molecules diminishes. When rupture occurs under a compressive stress, it is because the molecular actions developed in directions oblique to the line of thrust induce a tensile strain at right angles to this line, and a shearing strain in oblique directions, the resistance to one or the other of which is overcome. The distance *Oa* is not the limit to the possible diminution in the distance between the centers of contiguous molecules, since the act of compression will compress their envelopes, and so diminish the size of the effective molecules.

(5.) The ordinates of the portion *mc* of the molecular curve represent the effective attractions that come into operation during the act of rupture. That the rupture may be completed, a continued molecular strain must be exerted at least as great at each distance of separation, *O*3, as the effective resistance represented by the ordinate 3*u* at that distance. When the distance has increased to *Oc*, an effective repulsion supervenes, and the separation becomes complete.

Beyond *d* the curve represents the force of contact resistance. To test this portion of the curve, I undertook in 1876, to determine experimentally the laws of variation of this force. For this purpose the diminutions of contact distance produced by varying increments of pressure, under varying conditions with regard to the nature, condition, and extent of the surfaces in contact, were determined. The following are the general results obtained.*

(1.) The diminutions of contact distance are very nearly the same, for the same increments of pressure, whatever is the nature or condition of the surfaces in contact.

(2.) They are very nearly independent of the extent of the surface of contact.

(3.) The diminution of distance for a given increment of pressure (say 1 oz.), is nearly inversely proportional to the pressure.

Now, in correspondence with the first of these laws, it appears that at considerable distances beyond that, *Od* (fig. 1) of the maximum repulsion the curves answering to different values of k, and therefore to different materials, approach very near to each other, and beyond $100r$ are very nearly coincident, and have nearly the same inclination to the axis of x. This results from the fact that the attractive term in the formula for the effective force becomes at such distances very small, in comparison with the repulsive term which has the same value for different materials when the temperature is the same. To the same small diminution of distance should then correspond very nearly the same increment of the repulsive ordinate, for the molecular curve of each substance.

The second law follows as a consequence from the third.

As for the third law, it is to be observed that at the contact distances that obtained in the experiments, which must have been much greater than that, *Od*, answering to the maximum repulsive ordinate *dn*, the first term in equation (1), (p. 346) nearly vanishes, and so the effective repulsion (R) expressed by $R=\frac{m}{x^2}$, is nearly inversely proportional to the square of x. Theoretically then, the diminution of distance (dx) for small increments of the repulsion (dR) should be inversely proportional to $R^{\frac{3}{2}}$, or nearly so, instead of inversely proportional to R, as experiment showed. Here, as in previous cases, the discrepancy may reasonably be attributed to the compression of molecular envelopes that must attend the contact pressure; since such compression should increase the value of k, bring the repulsive portion *cn*, etc., (fig. 1) of the curve of effective molecular action nearer the axis *Ocd*, and so cause dx to decrease according to a less rapid law than would obtain if k and the corresponding curve remained constantly the same (which is represented by $\frac{1}{R^{\frac{3}{2}}}$.) In confirmation of this explanation it may be added that a change in the mechanical condition of the contact molecules, during contact pressure, correspondent to this theoretical interpretation, was directly revealed by the experiments.

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* See this Journal, June, 1876.

The experiments alluded to, besides revealing the laws of variation of the contact repulsion, showed that it was a force in operation beyond the range, *Oc*, of the effective molecular attraction, since no evidence of an attraction was obtained. They showed also that the increments of this force, attendant on the observed diminutions of molecular distance, were many times less than the increments of repulsion attendant on equal diminutions in the distance between the internal molecules of a body; in accordance with the indications of the molecular curve.

It will probably occur to the reader that our formula and curve of effective molecular action, afford no indication of a possible force of adhesive attraction, such as often manifests itself in the contact of surfaces. This defect results from the fact that the formula involves a supposition which is not strictly true in cases of contact. The more comprehensive formula is:

$$f=\frac{n}{(r+x)^2}-\frac{n'}{(2r+x)^2}-\frac{m}{x^2};$$

and equation (1) is obtained by supposing $n'=n$. This equality may not strictly exist in the contact of bodies, and n' may be less than n. I find that a slight excess of n above n' suffices to give an effective attraction for a certain range of values of x, for which f is repulsive according to equation (1). This case would be graphically represented by an upward inflection of the repulsive portion of the curve (fig. 1), bringing a portion of it above the axis of x. The attraction thus orginating should vary in its intensity at a given distance with the pressure, or molecular distance at contact, (i. e. graphically, the inflection of the curve should change); and recent experiments have shown this to be an essential feature of it, since it appears that pieces of plate glass in contact may be separated by the continuous exertion of a force ever so small.

I have now examined the general features of the typical molecular curve for solids, and shown that they represent diverse general mechanical properties of solids that have been experimentally ascertained. Let us now endeavor to subject the molecular formula (equation 2) to the test of comparison with experimental determinations of the coefficients of elasticity and tenacities of special substances. The direct means of accomplishing this would be to determine, if possible, the value of the ratio *k* for each material, and so obtain a series of definite expressions, or corresponding molecular curves, answering to the materials considered. But the value of *k* for a given substance is, from the nature of the case, incapable of direct determination. The only practicable method of proceeding is to assume, under the guidance of any intimations that may be obtained, a value of k for some substance, say wrought iron, taken as a standard of comparison; then the ratio which the coefficient of elasticity of any other material bears to that of wrought iron, will make known the value of its molecular ratio $\frac{2s}{a2}$ (fig. 1) at the neutral point, as compared with that of iron, and from this we may derive the comparative molecular curve for the material considered. The ratio of the maximum ordinate of this curve to that of the standard curve for wrought iron, will then make known the ratio of the tenacity of the material to that of wrought iron (account being taken of the comparative number of atoms, or ultimate molecules, of the two materials, in a unit of volume) and so enable us to compute theoretically its tenacity from the known tenacity of wrought iron. This computed value may then be compared with the tenacity as experimentally determined. In the prosecution of this inquiry, I assumed as the value of k for wrought iron, 12·41; taking for the coefficient of elasticity (E) 25,000,000 lbs., and for the tenacity 55,000 lbs. per square inch. The molecular curve for wrought iron would then be that shown in fig. 2, curve (a). The following notation and formulas were used in the calculations: N=number of atoms, or ultimate molecules in a unit of volume$=\frac{\text{specific gravity}}{\text{atomic weight}}$; n=number of atoms (ultimate molecules) in unit of length $=\sqrt[3]{N}$; E= coefficient of elasticity; T=tenacity; f=intensity of effective attraction between two contiguous molecules at the neutral distance, developed by an increment of distance, equal to $\frac{1}{10}r$. This, in fig. 1, is represented by the ordinate $2s$ corresponding to the small displacement $a2$. F=max. ordinate of the molecular curve. c, c', and c'' are constants.

$$E=c\frac{fn^2}{n}=cfn. \quad T=c'Fn^2.$$

Neutral distance, $d=\frac{r}{\log(1+100f)+u}$; in which u may be taken =zero for the metals generally and the more tenacious woods, for which k must have a value not widely different from that taken for wrought iron (12·41). For less tenacious materials u has a value increasing as k diminishes. For $k=$ 7·576, its value is 0·05. Its maximum value is $\frac{\cdot 1}{2\cdot 84}$, and obtains when $f=o$, in which case $k=4\cdot 934$, and the molecular curve falls entirely below the axis x. f is expressed in terms of $\frac{m}{r^2}$ or p, considered as unity (see page 346). For the more tenacious materials we may take, with but little error, $d=\frac{r}{\log 100f}$.

For calculating the maximum ordinate we have the formula, $F=\frac{c'}{d^{3\cdot 2}}$.* With these formulæ I have calculated the theoretical tenacities of a number of materials. The results are given in the following table, and compared with the tenacities obtained by experiment. With most of the materials the experimental determinations of coefficients of elasticity and tenacity used, are known, or there is good reason to believe, answer to the same specimen; but in the cases of zinc, brass, and tin, the coefficient of elasticity and the tenacity may have been obtained with different specimens.

Material.	Coeff. of Elas., E.	Tenacity.	
		Observed.	Calculated.
Wrought Iron	25,000,000 lbs.	55,000 lbs.	
Teak	2,214,000 "	15,000 "	14,600 lbs.
Locust	1,795,000 "	11,280 "	11,157 "
Oak	1,311,100 "	8,500 "	8,170 "
Scotch Fir	802,800 "	3,520 "	3,586 "
Copper	16,447,400 "	36,180 "	36,460 "
Zinc Wire	13,680,000 "	22,551 "	27,950 "
Brass, cast	9,170,000 "	18,000 "	20,300 "
Tin, cast	4,608,000 "	6,650 "	7,820 "
Lead	720,000 "	1,824 "	1,870 "

It seems from these results that our molecular formula (equation 2) enables us to compute the comparative tenacities of materials from their comparative coefficients of elasticity, with a close approximation to the truth; also that a scale of molecular curves may be deduced from it which serves to represent the comparative mechanical properties of different materials. The scale obtained rests on the assumption that the molecular curve for wrought iron is that answering to $k=12{\cdot}41$ (fig. 2) curve (*a*). But the laws of variation of the neutral distance, d, and the maximum ordinate, F, are so nearly constant over a wide range of variation in the value of k, and thus of the corresponding molecular curve, that the assumed curve for wrought iron might be considerably changed without materially impairing the correspondence between the computed and observed tenacities. The exponent of d in the expression for the maximum ordinate, which in the calculations was taken 3·2, varies only from 3·1 to 3·4 over the entire range of values of k from 20 to 5·4; and the value of u in the expression for the neutral distance varies only from zero to less than $\frac{1}{3}$.

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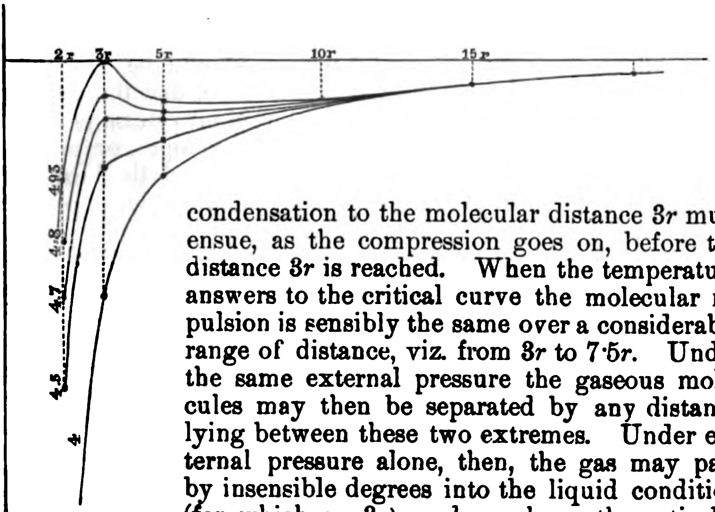
* Each molecule is subject to the action of several molecules, instead of the nearest one only, but the entire force taking effect on it is equal to the effective action of the nearest molecule multiplied by a factor which should be nearly constant for different materials.

It is important to remark, in this connection, that the complete molecular theory of the elastic resistance of materials cannot be developed from the single conception that each specimen of every material has its specific formula, or curve of effective molecular action, which remains constantly the same during all the varying conditions and degrees of stress. Thus when two specimens of the same material are compared, certain facts are recognized which require that account should be taken of the varying dimensions and mechanical condition of the molecules when under the influence of the force of stress. For example, the tenacities of two bars of wrought iron, or one bar of iron and another of steel, may be very different, though their coefficients of elasticity, E, may be nearly the same. The theoretical explanation of this fact, is that the molecular envelopes are drawn farther away from the central atoms of the molecules, and as a consequence the ratio k is increased, the molecular curve rises, and thus while the coefficient, E, for small displacements from the neutral distance is but little altered; the maximum ordinate, and so the tenacity, may be largely increased. It may be shown that the liability to this state of things exists with materials having a high value of k. The rise of the "limit of elasticity" as the result of the operation of a tensile stress to certain materials, and the augmentation of the tenacity of wrought iron bars by large tensile strains, as well as by a certain increase of temperature and by the process of thermo-tension, are other consequences of a similar molecular condition. It may be said in general that all the recognized deviations of property from the normal type of unvarying and perfect elasticity, while they must present insuperable obstacles to any molecular theory that does not recognize the "variability of the ultimate molecule," furnish to the present theory the occasion of its achieving one of its most signal triumphs.

Let us now subject the formula to the test of comparison with the laws and mechanical properties of vapors and gases. Upon the general theory the effective mutual actions of contiguous molecules of a vapor, or gas, must be repulsive. The curve of effective action of such a molecule must then lie entirely below the axis x; and hence it must answer to a value of k less than 4·934. Fig. 3 shows a set of theoretical curves answering to various values of k in equation 2, from 4·93 to 4. The vertical scale in this figure is 20 times that in fig. 2. These curves present two distinct varieties; one in which a portion of the curve is concave to the axis, x, and another in which the curve is everywhere convex to this axis. These two sets of curves have for their line of demarcation a curve in which a considerable portion is parallel to the axis. This curve answers to $k=4{\cdot}7$. The first or upper set of curves answers to vapors, and to gases when their temperature is such that they can be compressed into a liquid without further reduction of temperature. The reduction to a liquid by pressure alone is possible with some gases, (as sulphurous acid gas, chlorine, carbonic acid, etc.) at ordinary temperatures, and continuously up to certain higher temperatures. At these critical temperatures the curve becomes the critical curve just mentioned for which $k=4{\cdot}7$. Oxygen, hydrogen, etc., belong to a class of gases which cannot be condensed into a liquid unless the temperature is much reduced below ordinary temperatures. For these the smaller values of k obtain. The condensation into the liquid form is impossible because the repulsive ordinate steadily increases as the molecular distance x diminishes. A reduction of temperature diminishes the value of m, which is theoretically proportional to the absolute temperature, and so increases the value of k and causes the molecular curve to rise. When it is thus brought above the critical curve, for which $k=4{\cdot}7$, it becomes for a certain distance beyond $3r$ concave upwards, the effective repulsion begins to decrease at a certain distance beyond $3r$, and a sudden condensation to the molecular distance $3r$ must ensue, as the compression goes on, before the distance $3r$ is reached. When the temperature answers to the critical curve the molecular repulsion is sensibly the same over a considerable range of distance, viz. from $3r$ to $7{\cdot}5r$. Under the same external pressure the gaseous molecules may then be separated by any distance lying between these two extremes. Under external pressure alone, then, the gas may pass by insensible degrees into the liquid condition (for which $x=3r$), and we have theoretically the "continuity between the gaseous and liquid states of matter," experimentally realized by Dr. Andrews. The critical temperature for carbonic acid gas, Dr. Andrews found

3.



to be 31° C. At this temperature then the molecular curve for this gas was the curve for which $k=4·7$.

We have already seen that when a liquid reaches its boiling point in vacuo, its molecular curve is just tangent to the axis, x, at the point $x=2·84r$, and that $k=4·934$. When the liquid, say water, is subject to the atmospheric pressure, as the temperature rises above 72° F., (its boiling point in vacuo) and m continually increases, the curve subsides until the molecular repulsion, for $x=3r$, is just on the point of prevailing over the atmospheric pressure. The liquid will then be at its boiling point, 212° F. The slightest increase of heat repulsion will now cause the molecules to recede from each other, since the effective repulsive ordinates augment with the distance, x, and this recess should continue until the repulsive ordinate again becomes equal to the minimum value, that obtained when the recess began. To this tendency to a sudden separation of the molecules over a wide range of distance may be ascribed the agitation of the liquid, called boiling; and the amount of the final separation should fix the ratio of expansion in the passage of the liquid into vapor, at the boiling point. If the liquid boils under a higher pressure than one atmosphere, the access of heat augments the minimum molecular repulsion that obtains at about the distance $3r$, until it is on the point of prevailing over the actual pressure. The curve will now have subsided still more, and the recess of the molecules to the point at which the molecular repulsion becomes the same again, and so the expansion from the liquid to the steam at the higher boiling point and pressure, should be less than before (see fig. 3). It should be observed here, that the process of expansion in the conversion of the liquid into steam consists in part in an expansion of the molecular envelopes, or an enlargement of the effective molecules; and part of the heat lost is expended in thus augmenting the potential energy of the molecules.

When the reverse process occurs, and steam at 212° F. is condensed, the increasing repulsion shown by the curve is largely expended in condensing the molecular envelopes, with an attendant evolution of heat; and thus the process may set in as soon as the external pressure materially exceeds one atmosphere. A reduction of temperature brings on condensation by decreasing the value of m, which has the effect to raise the molecular curve, both by diminishing $p\left(=\frac{m}{r^2}\right)$ the unit in terms of which the repulsions are expressed, and increasing the ratio $k\left(=\frac{n}{m}\right)$.

[To be continued.]

ART. XLIII.—*On the Mineral Locality in Fairfield County, Connecticut, with the description of two additional new species;* by GEORGE J. BRUSH and EDWARD S. DANA. Second paper.

IN the preceding volume of this Journal (July and August, 1878), we published an account of the discovery of a new mineral locality at Branchville, Fairfield County, Connecticut, and gave descriptions of five new minerals, all manganesian phosphates, occurring there. During the autumn following we pushed forward our explorations at the locality with as much vigor as possible, and with tolerable success. We were fortunate in finding a new and independent deposit of the phosphates, and obtained from it a considerable quantity of eosphorite, lithiophilite and a little triploidite, and with them some other species of interest, among which we may mention a series of uranium compounds. The detailed description of these discoveries we shall defer until a third paper, which we hope to publish in another number. In the present paper we propose to give the descriptions of the two additional new species we have identified; one of these we mentioned in our last paper under the name of *fairfieldite.* We add also the results of a new analysis of reddingite, and some further facts in regard to lithiophilite. Both of the new species came from the original material, removed by Mr. Fillow, when the locality was first opened. We have not, as yet, succeeded in finding additional quantities of them. It may not be improper to add that with the return of warm weather we have commenced anew the exploration of the locality in a more thorough manner than before, and we hope to meet with some success.

6. FAIRFIELDITE.

General physical characters.—Fairfieldite occurs usually in massive crystalline aggregates; also rarely in distinct crystals. The structure is foliated to lamellar, some varieties closely resembling selenite; also occasionally in radiating masses consisting of curved foliated or fibrous aggregations; these radiated forms are not unlike stilbite.

The hardness is 3·5, and the specific gravity 3·15. The luster is pearly to sub-adamantine; on the surface of perfect cleavage (*b*) it is highly brilliant. The color is white to pale straw-yellow; the streak is white. Transparent. Brittle.

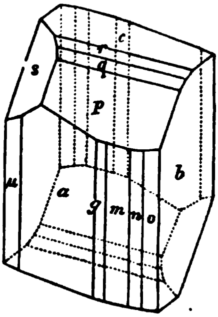
Two rather distinct varieties have been observed: the first (A) occurs filling cavities in the reddingite, and covering the distinct crystals of this mineral. It is uniformly clear and transparent, and is highly lustrous, showing entire absence of even incipient alteration. It is generally foliated to lamellar, although sometimes of a somewhat radiated structure. The second variety (B) occurs in masses of considerable size interpenetrated rather irregularly with quartz, and quite uniformly run through with thin seams and lines of a black manganesian mineral of not very clearly defined character. This mineral is granular in texture, lustrous, is difficultly fusible, and consists for the most part of the hydrated oxides of manganese and iron; but contains also phosphoric acid and traces of lime.

This second variety of fairfieldite is often friable to the touch and lacks something of the brilliant luster of the first variety. It also shows greater difference of structure, passing from the distinct crystals to the massive and radiated form. The identity of these two kinds is shown by the analyses given below. Fairfieldite also occurs in small particles in fillowite (described beyond), and in masses of some size immediately associated with eosphorite, triploidite, and dickinsonite.

Crystalline form.—Indistinct crystals of fairfieldite occur occasionally in cavities in the massive mineral. They are usually composite in character, made up of many individual crystals, interpenetrating each other, and in only an approximately parallel position. On the most favorable crystals the form could be clearly made out, but exact measurements were quite impossible; this is the more to be regretted as the number of variable elements is so large. The cleavage parallel to *b* (010) is highly perfect; that parallel to *a* (100) somewhat less so.

The crystals belong to the *Triclinic System*, and the general habit is shown in the adjoining figure. The following supplement angles were accepted as the basis of the calculations.

$a \wedge c$	$100 \wedge 001$	=	88°
$a \wedge b$	$100 \wedge 010$	=	102°
$a \wedge p$	$100 \wedge 111$	=	56° 30′
$c \wedge p$	$001 \wedge 111$	=	33°
$b \wedge p$	$010 \wedge 111$	=	78° 30′



From these angles, the lengths and mutual inclinations of the axes were calculated, as follows:—

	c (vert.)	$\bar{b}$	$\breve{a}$
	·7065	3·5757	1·0000 or
	·1976	1·0000	·2797
Also	$\alpha\ (c \wedge \bar{b})$	$\beta\ (c \wedge \breve{a})$	$\gamma\ (\bar{b} \wedge \breve{a})$
	102° 9′	94° 33′	77° 20′

The observed planes are as follows:—

c	O	001	*s*	$-4\text{-}\breve{4}$	$1\bar{4}1$
b	$i\text{-}\breve{i}$	010	*g*	$i\text{-}\bar{\tfrac{3}{2}}'$	320
a	$i\text{-}\bar{i}$	100	*m*	I'	110
p	$-1'$	111	*n*	$i\text{-}\breve{\tfrac{3}{2}}'$	230
q	$-\tfrac{1}{2}'$	112	*o*	$i\text{-}\breve{2}'$	120
r	$-\tfrac{1}{3}'$	113	*μ*	I	$1\bar{1}0$

The following list includes the principal angles (supplement) for the different planes, calculated from the axial values given above.

		Calculated.	Measured.
c ∧ *a*	001 ∧ 100	= 88°	*88°
c ∧ *b*	001 ∧ 010	= 78° 33′	79°
c ∧ *m*	100 ∧ 110	= 84° 39′	
c ∧ *p*	001 ∧ 111	= 33°	*33°
c ∧ *q*	001 ∧ 112	= 18° 31′	19°
c ∧ *r*	001 ∧ 113	= 12° 43′	13°
c ∧ *s*	001 ∧ $1\bar{4}1$	= 53° 34′	
a ∧ *b*	100 ∧ 110	= 102°	*102°
a ∧ *g*	100 ∧ 320	= 10° 57′	10°
a ∧ *m*	100 ∧ 110	= 16° 31′	16° 30′
a ∧ *n*	100 ∧ 230	= 24° 40′	25°
a ∧ *o*	100 ∧ 120	= 32° 20′	32°
a ∧ *μ*	100 ∧ $1\bar{1}0$	= 14° 45′	16°
a ∧ *p*	100 ∧ 111	= 56° 30′	*56° 30′
a ∧ *q*	100 ∧ 112	= 70° 15′	
a ∧ *r*	100 ∧ 113	= 75° 48′	
a ∧ *s*	100 ∧ $1\bar{4}1$	= 51° 17′	
b ∧ *μ*	010 ∧ $1\bar{1}0$	= 116° 45′	
b ∧ *g*	010 ∧ 320	= 91° 3′	
b ∧ *m*	010 ∧ 110	= 85° 29′	
b ∧ *n*	010 ∧ 230	= 77° 20′	
b ∧ *o*	010 ∧ 120	= 69° 40′	
b ∧ *p*	010 ∧ 111	= 78° 30′	*78° 30′
b ∧ *q*	010 ∧ 112	= 78° 2′	78°
b ∧ *r*	010 ∧ 113	= 78° 4′	
b ∧ *s*	010 ∧ $1\bar{4}1$	= 121° 16′	120° 30′
m ∧ *p*	110 ∧ 111	= 51° 39′	
m ∧ *q*	110 ∧ 112	= 66° 8′	
m ∧ *r*	110 ∧ 113	= 71° 56′	

In one case an apparent penetration-twin was observed, the two crystals crossing one another so that the planes *b* and *a* of the one were parallel respectively to the planes *a* and *b* of the other. If this coincidence were perfect (exact measurement was out of the question) and the crystal were really a twin the twinning-plane must make with *a* (100) an angle of either 51° (toward 010) or 39° (toward $0\bar{1}0$). This condition is equally well satisfied by the plane 270 ($100 \wedge 270 = 51° 4'$), or by $2\bar{7}0$ ($100 \wedge 2\bar{7}0 = 39° 3'$.) As this supposed twinning-plane has so complex a relation to the other planes of the crystal, it is probable that this coincidence is only accidental.

Optical properties.—Minute fragments of fairfieldite parallel to the two cleavage planes were examined in the stauroscope, with the following results:—The planes of light-vibration intersect the cleavage plane *a* (100) in lines which make angles of 40° and 50° respectively with the edge $a \mid b$. One optical axis was visible on the edge of the field in converging light, obviously lying in the vibration-plane making an angle of 50° with the obtuse edge named, and toward that edge.

The cleavage plane parallel to *b* (100) is intersected by the vibration planes in lines making angles of 10° and 80° respectively with the edge $b \mid a$. In this case also an optical axis (the second) is distinctly visible on the outer limit of the field. This serves to fix approximately the position of the bisectrix. As the cleavage fragments examined were less than ½ mm. in size, any further examination was impossible.

Chemical Composition.—The two varieties of fairfieldite have been analyzed by Mr. S. L. Penfield, with the following results:

	A.	B.
P_2O_5	38·39	39·62
FeO	5·62	7·00
MnO	15·55	12·40
CaO	28·85	30·76
Na_2O	0·73	0·30
K_2O	0·13	....
H_2O	9·98	9·67
Quartz	1·31	0·55
	100·56	100·30

The ratios of the oxides calculated from these analyses are as follows:—

		A.			B.	
P_2O_5	·270	·270	1	·279	·279	1
FeO	·078	·825	3·06	·097	·826	2·96
MnO	·219			·175		
CaO	·515			·549		
Na_2O	·012			·005		
K_2O	·001			...		
H_2O	·554	·554	2·05	·537	·537	1·93

The ratio $P_2O_5 : RO : H_2O = 1 : 3 : 2$ answers to the formula $R_3P_2O_8 + 2$ aq. If here $R = Ca : Mn + Fe = 2 : 1$ and the ratio of $Mn : Fe$ be also $2 : 1$. The formula requires:—

P_2O_5	39·30
FeO	6·64
MnO	13·10
CaO	30·99
H_2O	9·97
	100·00

The fact that the second variety was friable and somewhat deficient in luster suggested an incipient alteration, but the analysis did not confirm this idea. The larger amount of lime afforded in the analysis of this kind is possibly due to admixture of a little apatite, which is often observed with it, and the larger proportion of iron may be due to the fact that this variety could not be entirely freed from the black oxide interpenetrating it.

Pyrognostics.—In the closed tube fairfieldite gives off neutral water, and the assay turns first yellow, then dark brown, and becomes magnetic. In the forceps glows, blackens and fuses quietly at about 4·5 to a dark yellowish-brown mass, coloring the flame pale green, with faint reddish-yellow streaks on the upper edge. Soluble in the fluxes giving reactions for iron and manganese. Fairfieldite is soluble in nitric and hydrochloric acids.

Fairfieldite is named from the county in which the locality occurs.

7. Fillowite.

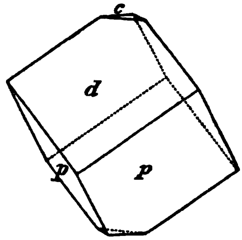
General physical characters.—Fillowite occurs in granular crystalline masses. By fracture the crystalline grains can be usually separated with ease; they show in most cases merely striated planes of contact, having no crystallographic significance; occasionally, however, isolated but brilliant crystalline planes are observed and rarely a nearly complete crystal. The masses are not infrequently penetrated by distinct prismatic crystals of triploidite; and sometimes they enclose particles of fairfieldite. The outer surfaces are very often coated with a silvery-white radiated mineral, but in so sparing quantities that we have been thus far unable to determine definitely its character. Reddingite is very commonly associated with fillowite, and in many cases it is not easy to distinguish the two minerals.

The hardness is 4·5, and the specific gravity in two trials 3·41 and 3·45. The luster is sub-resinous to greasy. The color generally wax-yellow, also yellowish to reddish-brown with a red or green tinge, and rarely almost colorless. Streak white. Transparent to translucent; fracture uneven; brittle.

Crystalline form.—The crystals of fillowite, whose occurrence has already been mentioned, have a marked rhombohedral aspect. As shown in the figure the three planes, whose several inclinations are almost identical, have their common solid angle replaced by a nearly equilateral triangle. The measurements, however, point to a monoclinic form, and that this is the true explanation is proved by the optical examination. The cleavage is basal, nearly perfect.

The angles (supplement) accepted as the basis for calculation, are as follows:—

$c \wedge p \quad 001 \wedge \bar{1}11 = 58^\circ\ 40'$
$c \wedge d \quad 001 \wedge 201 = 58^\circ\ 31'$
$p \wedge p \quad \bar{1}11 \wedge \bar{1}\bar{1}1 = 95^\circ\ 23'$



Calculated from these the elements of the crystal are:—

c (vert.)	b	ă	β
·8201	·5779	1·0000 or	89° 51′
1·4190	1·000	1·7303	

The position taken for the crystal is that which exhibits most strikingly its close approximation to the rhombohedral form. If it were desired to make the plane *d* the unit orthodome $\bar{1}01$, then the plane *p* would have the symbols 111 and $1\bar{1}1$, and the elements of the crystal would be:— $\beta=73^\circ\ 11'$; c (vert.)$=1·1422$, $b=0·578$, ă$=1·000$.

The observed planes have already been given; they are:—

c 001 *O.* *d* 201 —2-*i.* *p* $\bar{1}11$ 1.

The calculated angles and those measured (on two crystals) are:—

			Calculated.	Measured. (1)	(2)
$c \wedge d$	$001 \wedge 201$	=	58° 31′	*58° 31′	
$c \wedge p$	$001 \wedge \bar{1}11$ $001 \wedge \bar{1}\bar{1}1$	=	58° 40′	*58° 40′ 58° 37′	
$p \wedge p$	$\bar{1}11 \wedge \bar{1}\bar{1}1$	=	95° 23′	*95° 23′	95° 25′
$p \wedge d$	$\bar{1}11 \wedge 201$ $\bar{1}\bar{1}1 \wedge 201$	=	95° 20′	95° 20′ 95° 16′	95° 15′ 95° 18′

Optical properties.—It was found possible to examine small cleavage fragments of fillowite according to the usual methods, and the results served to settle the question of the system, which the measured angles might have left undecided. One vibration-plane intersects the basal plane (cleavage) parallel to the edge $c|d$ and the other is normal to it. Moreover the two optic axes are visible when the Rosenbusch microscope is employed; it was impossible to decide, however, in which plane they lay, since the only sections transparent enough for this examination were destitute of the other crystalline planes.

Chemical properties.—The analyses of fillowite by Mr. S. L. Penfield afforded the following results:—

	I.	II.	Mean.		Ratios.	
P_2O_5	39·06	39·15	39·10	·275	2·75	1
FeO	9·48	9·18	9·33	·129	8·51	3·09
MnO	39·48	39·36	39·42	·555		
CaO	undet.	4·08	4·08	·073		
Na_2O	5·65	5·84	5·74	·092		
Li_2O	·07	·04	·06	·002		
H_2O	1·75	1·56	1·66	·092	·92	0·33
Quartz	0·86	0·90	0·88			
		100·11	100·27			

The ratio $P_2O_5 : RO : H_2O = 1 : 3 : \frac{1}{3}$, corresponds to the formula $3R_3P_2O_8 + H_2O$. If in this formula $R = Mn : Fe : Ca : Na_2 = 6 : 1 : 1 : 1$ the calculated percentages are:—

P_2O_5	40·19
FeO	6·80
MnO	40·19
CaO	5·28
Na_2O	5·84
H_2O	1·70
	100·00

The very small amount of water present suggests the question as to whether it is really an original constituent of the mineral. This question we have been unable to decide positively; we can only add that of a large number of specimens examined, all, even the most transparent, showed its presence. Moreover, if the water be not essential, the composition of the mineral would be somewhat analogous to triphylite, containing sodium instead of lithium, and the want of correspondence in crystalline form does not favor this idea.

Pyrognostics.—In the closed tube fillowite yields a small amount of water which reacts neutral. B.B. in the forceps colors the flame momentarily pale green, then intensely yellow and fuses with intumescence to a black feebly magnetic globule. Fusibility 1·5. With the fluxes reacts for iron and manganese. Soluble in nitric and hydrochloric acids.

We have named this the *seventh* new manganesian phosphate from this locality, after Mr. A. N. Fillow, of Branchville, Conn., our obligations to whom we have already mentioned in our former paper.

REDDINGITE.

In our preceding paper we described the new mineral reddingite, and showed that in the habit of its octahedral crystals and in their angles it was closely homœomorphous with scorodite and strengite. In composition, however, it was shown that there was a variation, as follows:—

Scorodite	$\text{FeAs}_2\text{O}_8+4\text{aq.}$
Strengite	$\text{FeP}_2\text{O}_8+4\text{aq.}$
Reddingite	$\text{Mn}_3\text{P}_2\text{O}_8+3\text{aq.}$

It is thus seen that reddingite differs from the other species in that the metal is in the protoxide condition, and again since there are only three equivalents of water present. In order to establish beyond all question that this difference was a real one, we have had a second analysis made. The material was selected from another specimen, and as before, was obtained free from all impurities except quartz.

The analyses, made by Mr. H. L. Wells, are given below (A) as also that of Mr. Penfield (B) published in our preceding paper:—

	I.	II.	A Excluding Quartz.	B
P_2O_5	33·58	....	35·16	34·52
FeO	7·54	....	7·89	5·43
MnO	41·28	....	43·22	46·29
CaO	0·67	....	·71	0·78
Na_2O	trace	....	....	0·31
H_2O	11·72	11·72	12·27	13·08
Quartz	4·46	4·39		
	99·25		99·25	100·41

The new analysis leads to the formula $\text{Mn}_3\text{P}_2\text{O}_8+3\text{aq}$, or the same as that obtained before. The only marked difference between the two results is one which we have found to characterize all the species of the locality, that is, a little variation in the relative amounts of iron and manganese. That the manganese is really in the protoxide condition cannot be questioned for a moment.

Recapitulation.

It seems of some interest to place together the seven new species which the locality has afforded us. We shall hope, at some future time, to offer some remarks in regard to their mutual relations; we can only say here that there is in the facts observed nothing to suggest that any one of the species is a secondary mineral or a product of alteration; all seem to be original minerals of the vein. We have found single hand-specimens which exhibit all of the first four minerals together.

1. **EOSPHORITE.** Orthorhombic.
$\text{R}_3\text{AlP}_2\text{O}_{10}, 4\text{H}_2\text{O}$, or $\text{AlP}_2\text{O}_8+2\text{H}_2\text{Mn(Fe)O}_2+2\text{aq.}$

2. **TRIPLOIDITE.** Monoclinic.
$\text{R}_4\text{P}_2\text{O}_9, \text{H}_2\text{O}$ or $\text{Mn}_3(\text{Fe}_3)\text{P}_2\text{O}_8+\text{Mn(Fe)(OH)}_2$

3. **DICKINSONITE.** Monoclinic.
$4(\text{R}_3\text{P}_2\text{O}_8), 3\text{H}_2\text{O}$ or $4(\text{Mn, Fe, Ca, Na}_2)_3\text{P}_2\text{O}_8+3\text{aq.}$

4. **Lithiophilite.** Orthorhombic.
$LiMnPO_4$ or $Li_3PO_4 + Mn_3P_2O_8$.

5. **Reddingite.** Orthorhombic.
$R_3P_2O_8$, $3H_2O$ or $Mn_3(Fe_3)P_2O_8 + 3aq$.

6. **Fairfieldite.** Triclinic.
$R_3P_2O_8$, $2H_2O$ or $Ca_2(Mn_3, Fe_3)P_2O_8 + 2aq$.

7. **Fillowite.** Monoclinic.
$3(R_3P_2O_8)$, H_2O or $3(Mn, Fe, Ca, Na_2)_3P_2O_8 + aq$.

Altered Lithiophilite.

In our former paper we called attention to the large amount of black oxidized material rich in lithia which was associated in the first deposit with eosphorite, triploidite and dickinsonite. We stated also, that the occurrence of this black substance induced us to make the deeper exploration which resulted in the discovery of lithiophilite. We have now made a more critical examination of this black mineral, and have found on breaking it up into very small fragments occasional kernels or nuclei, often no larger than a pea, of unaltered lithiophilite. By far the greater part of the black masses, however, have proved to be oxidized to the core. The black material varies considerably in its structure; some specimens retain with great distinctness the cleavage of the original lithiophilite; other fragments break with a conchoidal fracture, while still other specimens form porous, crumbly, loosely aggregated masses. The color of the mineral also varies; it is generally grayish-black to pitch-black; occasionally, however, it has a purple to violet color, the latter being due apparently to a different state of oxidation of the manganese and iron. That this is the case seems to be proved by the fact that the black variety can be made to assume a purple hue by dipping it in hydrochloric acid; the mass so treated becomes at once colored purple externally, and is not to be distinguished from a specimen of the naturally occurring purple mineral. The luster varies from sub-resinous to dull. Hardness 3–4. Specific gravity 3·26–3·40. It is not to be expected that in such an alteration product the chemical composition should be constant. We have had two characteristic specimens analyzed and give the results below. The first was of the cleavable variety, having a nucleus of unaltered lithiophilite, and was analyzed by Mr. F. P. Dewey, in the Sheffield Laboratory, G.=3·39–3·40.

	I.	II.	Mean.		Atomic Ratios
P_2O_5	40·79	40·53	40·66		·286
Fe_2O_3	12·55	12·57	12·56		·079
Al_2O_3	0·10	0·09	0·10		·001
MnO	35·83	35·66	35·74	= 25·27 Mn_2O_3	·160
O in excess	1·20	1·18	1·19	11·66 MnO	·164
CaO	0·13	0·23	0·18		·003
MgO	*tr.*	*tr.*	*tr.*		
Li_2O	5·71	5·61	5·66		·188
Na_2O	0·44	0·53	0·49		·008
H_2O	3·11	3·03	3·07		·170
	99·86	99·43	99·65		

Another specimen of the more compact dull variety analyzed by H. L. Wells, afforded the following results:—G. = 3·26–3·27.

	I.	II.	Mean.			Atomic ratio.		
P_2O_5	40·25	40·51	40·38			·284		1
Fe_2O_3	16·04	15·74	15·89			·099	·191	
MnO	32·07	31·99	32·03	= Mn_2O_3	14·71	·092		
O in excess	1·47	1·50	1·48	MnO	18·80	·265	·339	2·88
CaO	·74	·70	·72			·010		
Li_2O	4·69	4·96	4·83			·161		
K_2O	0·25	0·28	0·26			·003		
Na_2O	*tr.*	*tr.*	*tr.*					
H_2O	3·32	3·41	3·37			·187		
Residue	0·90	0·90	·90				·187	
			99·86					

This last variety approaches the composition of a normal phosphate, but as before remarked it is not to be expected that such products of alteration should be homogeneous or prove to be definite mineral species. In general the above analyses show a marked correspondence with the analogous product of the alteration of the Norwich triphilite as analyzed by Craw and Mallet. The Branchville black material is, however, richer in manganese and in lithia, and fortunately we find it enveloping unaltered lithiophilite so that there can be no question as to the character of the original mineral.

In order to avoid any misunderstanding we may repeat here a remark already made, that we have observed also a variety of other black decomposition products bearing no relation to the above. One of them contains the oxides of iron and manganese simply being derived from the alteration of the carbonate (rhodochrosite); others have been derived respectively from the decomposition of eosphorite, triploidite and reddingite. The last named has often the characteristic octahedral form of the original mineral.

We would express here our sincere thanks to the three gentlemen, Messrs. Penfield, Wells and Dewey, who have assisted us in the chemical part of this investigation.

ART. XLIV.—*Note on the Fox Hills Group of Colorado;* by J. J. STEVENSON, Professor of Geology in the University of New York.

NOT far from thirty miles below (north) Denver, St. Vrain's Creek enters the South Platte River from the west. The Thompson enters from the same side several miles above Evans, or about forty-five miles below Denver; and the Cache La Poudre, in like manner, enters somewhat more than fifty miles from Denver. The towns of Evans and Greeley lie close together, the former being on the South Platte River almost fifty miles from Denver.

In 1873, I visited this region and made some observations, which were published shortly afterward. As the conclusions, which I then reached, were called in question, I took occasion before entering the field in 1878 to revisit the locality.

A line of bluffs begins on the west side of the South Platte River at a little way below the mouth of St. Vrain's Creek, and continues until within a mile or two of Thompson Creek. This bluff is more or less distinct on the north side of the St. Vrain for nearly four miles from its mouth. Similar bluffs are conspicuous along the northerly bank of Thompson for several miles, and can be traced thence to near the Cache La Poudre without any difficulty.

A low bluff-like ridge, lying at from one to three miles from the river, begins at Platteville on the east side of the stream, and is easily followed to a considerable distance northeastward from the town of Evans.

In the bluffs lying on the west side of the Platte, the rocks dip gently northward. On the opposite side the dip is insignificant; a very gentle anticlinal was observed at Platteville, and the rocks are almost horizontal or possibly dipping slightly toward the north at four miles southeast from Evans.

On the West side of the South Platte River.—Following the grade of the Colorado Central Railroad on the west side of the river, one finds, somewhat more than four miles above Evans, an outcrop of bright yellow, very friable sandstone, forming a broad band on the bluff. Fragmentary outcroppings of the same rock were observed farther down the river, but here for the first time the exposure is satisfactory.

On the Thompson, the exposure ends with the curving bluff at probably five miles from the river, and the dip along the stream is insignificant.

As already stated, the bluff begins again on the south side of the Thompson probably two miles from that stream, and is continuous thence to within a short distance of the St. Vrain.

Here again is a fine exposure of the sandstone which shows a gentle east-northeast dip. The section up to the St. Vrain is as follows, the thicknesses being estimated:

1.	Yellow sandstone	450 feet.
2.	Blue sandstone	200 "
3.	Concealed	200 "
4.	Yellow sandstone	100 "
5.	Gray to blue sandstone	50 "
	Total	1,000 "

No. 1, the sandstone already referred to as occurring in the bluffs both north and south from the Thompson, is bright yellow and for the most part extremely friable, weathering easily and breaking down into loose sand. But, at irregular intervals, vertically, it shows thin layers of darker sandstone, some of which are quite compact, while others are flaggy, though they all resist the action of the weather. The unequal resistance to the weather is so marked that south from the Thompson the bluffs are known as the Monument Bluffs. The features are exactly the same as those shown in Monument Park, north from Colorado Springs, and the peculiar forms exhibited in photographs, taken by Mr. Jackson in that Park, are accurately reproduced here. So closely do the rocks on the Platte and St. Vrain resemble those in Monument Park, that one might well be tempted to imagine that they are parts of one series, and that the series is continuous along the whole face of the mountain.

This locality was visited by me in 1873,* in company with Mr. J. A. P. Kelley of Evans. and in 1878 with Dr. J. Innes and Mr. S. A. Stevenson of Evans, and Mr. A. J. McClure of Bellefonte, Penn. For the greater portion, the soft, yellow sandstones are devoid of fossils, but here and there *Halymenites major* Lesqx. occurs, and occasionally one stumbles on a little nest of *Ostrea*. The harder layers are quite different, many of the more compact being crowded with the *Halymenites*, while most of the flaggy layers contain Fox Hills fossils, among which are *Ammonites lobatus*, *Nucula cancellata*, *Mactra Warrenana*, and numerous other species. Other layers are crowded with fragments of carbonized wood, and frequently one finds in such layers oblong cavities, six inches long, filled with carbonaceous matter in oolite grains and closely resembling the roe of a large fish. In 1873, Mr. Kelley discovered a thin layer containing impressions of dicotyledonous leaves. But the leaf specimens, with nearly all the other specimens obtained during that visit, were destroyed by an accident to the building where they were stored in Evans. During my last visit the leaf bed could not be found.

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* Notes on the observations made in 1873 were published in the Proc. Lyc. Nat. Hist. of N. Y. for Jan., 1874; in the Proc. Amer. Phil. Soc. for 1875; and in the report to Lt. Wheeler, published in 1876.

These fossils can be procured between the Thompson and St. Vrain from a high knob near the Stone House, but localities are numerous both north and south from the Thompson, specimens having been obtained by me from both sides of that stream, and from the north side by persons connected with the Geological Survey of the Territories.

The blue sandstone appears first above the Stone House, and physically differs little from the overlying yellow sandstone. It contains, however, no inconsiderable proportion of shale, while shaly layers are few in the other rock.

The interval, No. 3, as given in the section is too small, but no direct means of determining the thickness was at my disposal, and the calculation was made roughly by depending on the rate of dip at the southern termination of the bluffs at St. Vrain. The sandstones at the base of the section are exposed on the St. Vrain at nearly three miles from the river. They resemble the higher sandstones in structure, and as far as examined proved to be non-fossiliferous.

The relation of this enormous mass of sandstone to the coal beds mined by the St. Vrain Company could not be made out directly, as there is no way of connecting the exposures; but a barometric line carried over to the mines seems to indicate that the coal at those works lies not far from the horizon of the concealed interval. There is no evidence that any faults exist in this vicinity. Coaly material was obtained in borings, begun on the north side of St. Vrian in the sandstone at the base of the section.

On the East side of the South Platte River.—In 1874, Dr. J. Innes made several borings in search of coal at about five miles southeast from Evans. No. 1 was begun in dull, yellow sandstone, moderately coarse, containing small ferruginous nodules with *Halymenites major* and shells; but only fragments of the latter were seen, sufficient, however, to show that they belong to characteristic species of the Fox Hills group. This boring was carried 268 feet and gave the following section:

1.	Sandstone	52	feet.
2.	Carbonaceous shale	4	"
3.	Yellow sandstone	10	"
4.	Light shale	50	"
5.	White sandstone	40	"
6.	Blue shale	10	"
7.	Blue sandstone	10	"
8.	Alternations of sandstone and shale	92	"
	Total	268	"

Certainly very different from anything exposed on the western side of the river. The rocks here are almost horizontal, but there seems to be a very slight dip toward the north. Accompanied by Dr. Innes, and Messrs. Miller and Stevenson of Evans, I followed up the gulch from this boring to No. 2, which is but a short distance from the last and only a few feet higher. Between the two is a blossom of *coal* or carbonaceous shale. Almost immediately north from the gulch and at barely 100 feet above No. 1, a third boring was put down, in which the following section was obtained:

1.	Dirt	10	feet.			
2.	Sandstone	10	“			
3.	Fire clay	2	“			
4.	Sandstone	14	“			
5.	*Black shale*	16	“			
6.	Sandstone	21	“			
7.	Fire clay	1	foot.			
8.	*Coal* with a little shale	2	feet	10	inches.	
9.	Interval	28	“	3	“	
10.	*Coal*	0	“	2	“	
	Total	105	“	3	“	

The black shale, No. 5, is very carbonaceous throughout, and No. 10 is in close proximity to the dark shale or *coal* seen between borings No. 1 and No. 2, which rests almost directly on the sandstone at the top of the section in No. 1.

At fourteen feet above the curb of this boring, a shaft was begun in order to reach the *coal bed*, No. 8 of the section; but after it had been sunk to a depth of twenty-eight feet, Dr. Innes made a boring to determine the character of the coal once more. In this, the upper portion of the shale, No. 5 was found to be a *coal bed* two feet seven inches thick; the *coal bed*, No. 8, was unchanged in thickness, while the little bed at the bottom of the third boring had swelled to six inches. But of the three beds only the middle one showed good coal, that from the others being very soft and of not merchantable quality.

The shaft shows 10 feet of debris resting on eighteen feet of sandstone. The latter contains several fine-grained, somewhat ferruginous layers, which are crowded with remains of Fox Hills species, of which many weathered specimens still lie round the dump. The best specimens obtained were carried away as the work advanced, but a box of them was selected by Dr. Innes, and sent to me in 1874 by Mr. J. A. P. Kelley of Evans. This contained the following species: *Ammonites lobatus*, *Cardium speciosum*, *Nucula cancellata*, *Mactra alta*, *Mactra Warrenana*, *Lunatia Moreauensis* and undetermined species of *Anchura.* Fragments of these were seen on the dump, and some good specimens of the univalves were obtained.

At a little distance from this shaft another boring was made, which shows eleven beds of coal in the same interval, which vary in thickness from two to thirty-one inches.

One cannot join the exposures on the east, with those on the west side of the river, as the terraced plains of the Platte are very broad from Platteville to far below Evans. At the same time, the fucoids and the mollusks are fully characteristic of the Fox Hills group, and show that the rocks on both sides of the river are of the same age. Those on the east side have been regarded as without doubt belonging to the Laramie, not to the Fox Hills Group.

The bluffs on the west side between the Thompson and the St. Vrain have been colored as *Laramie* on Dr. Hayden's map. These bluffs show Fox Hills fossils to the top; they contain no coal; no leaf-impressions were found by Dr. Hayden's corps. It is difficult to understand, therefore, why the richly fossiliferous sandstones of the bluffs should be colored as Laramie, while the underlying sandstones, without characteristic features, should be colored as Fox Hills. The bluffs along the Platte, both north and south from the Thompson and those on both sides of the Thompson, are *Fox Hills* and *Fox Hills* only. No higher rocks are exposed between Thompson and St. Vrain within five miles west from the Platte.

ART. XLV.—*Note on the Spectrum of Brorsen's Comet;* by Professor C. A. YOUNG, of Princeton, N. J.

AFTER several unsuccessful attempts, I have at last, on April 1st and 2d, obtained fairly satisfactory observations of the spectrum of this comet. It consists of three bands, like the spectra of all the other comets hitherto observed, the bands being well defined at the lower (least refrangible) edge and fading out towards the upper. The spectrum is so faint that observation is very difficult, and I was able to determine the position of only one of the bands—that in the green, which is much brighter than the other two.

The instrument employed was the 9½ inch refractor of our new observatory, armed with a one-prism spectroscope of sufficient dispersive power to separate the D lines clearly; the eye-piece has a micrometer which carries a bar thick enough to be seen on the back-ground of even a very feeble spectrum. The observation was made by placing the bar so that the bright edge of the band should be just visible as a thin line, the rest of the band being occulted. The instrument has also a scale like that of the ordinary chemical spectroscope, and the position of the micrometer-bar is determined both by the reading of the micrometer-screw and by the reading of the scale, illuminated for a moment after the bar has been set.

On April 1st I got three scale readings—respectively 99·9, 100·0 and 100·4, the value of one scale division in this part of the spectrum being very nearly 25 units of Ångström's scale, or about double the distance between the extreme lines of the *b* group, the readings decreasing with the wave length.

Just before dark b_1 in the spectrum of daylight coincided with 100 on the scale; also, immediately after the third pointing and without disturbing the telescope, spectroscope, or micrometer, the flame of a Bunsen burner was presented to the slit, and the lower edge of the green band in the well-known spectrum of this flame was found to show itself at the edge of the occulting bar precisely where the comet spectrum had been. We may therefore fairly conclude that the lower edge of the central band in the comet spectrum had a wave length of very nearly 517 millionths of a millimeter. The observation of April 3d confirms this, though but a single reading could be obtained. The only special interest in this observation lies in the fact that in 1868 Mr. Huggins obtained a somewhat different result for this same comet.

In an elaborate paper published some years ago by Vogel in Poggendorff's Annalen upon the spectra of comets, he comes to the conclusion that there are several different kinds of cometary spectra, the differences lying merely in the wave-length of the bands. But he seems to have reached this conclusion by assigning rather too high a degree of accuracy to the observations. With the exception of Brorsen's comet, it would seem that the discrepancies between the different results are entirely within the range of probable error, and that there is no valid reason for supposing more than a single cometary spectrum, slightly modified in different comets by differences of pressure and temperature.

It would now appear from my observations that Brorsen's comet also must fall into line with the rest.

I am entirely at a loss how to explain Mr. Huggins's result. It can hardly be that the comet has really changed its spectrum in the meanwhile, and a careful reading of his account (Proc. of the Royal Society, vol. xvi, p. 388) gives no light as to how an error could have crept into his work; on the other hand, every precaution would seem to have been taken.

However this may be, I am quite positive as to the accuracy of my present result—that the middle band of the spectrum of this comet now coincides sensibly (to a one-prism spectroscope) with the green band in the hydrocarbon spectrum.

The comet is moving very nearly in the path assigned by the ephemeris of Schulze. It is easily visible in the 3-inch finder of the equatorial, and in the telescope itself appears as a round nebulosity, between 30″ and 40″ in diameter, without definite nucleus, though much brighter in the center. Before the new moon a faint tail was visible, about one-half degree in length. It appeared like a thin streamer, much narrower than the head of the comet, perfectly straight, and directed from the sun.

Princeton, N. J., April 5, 1879.

ART. XLVI.—*On the Hudson River Age of the Taconic Schists, and on the Dependent Relations of the Dutchess County and Western Connecticut Limestone belts;* by JAMES D. DANA.

THE paper by the writer on the Relations of the Geology of Vermont to that of Berkshire, in volume xiv of this Journal (1877), closed (on p. 264) with the following paragraph:

"The magnitude of the results are strong evidence that the so-called limestone-area is really but a small part of a larger region of cotemporaneous disturbance and uplift. The true breadth of the area, as well as length—whether it reached to the Connecticut Valley on the east and to the Hudson River Valley on the west, and so had the breadth of the Appalachian disturbance of a later epoch, or whether it had narrower limits—may be ascertained by studying the stratification. Some of the results of such a study as regards Connecticut and a portion of New York I propose to give in another paper."

Since the above was written I have spent much time in endeavoring to complete my observations in Connecticut and the neighboring counties of New York. I have sought to determine the strike and dip and stratigraphical relations of the rocks of Western Connecticut—points on which Percival's Report contains little, since he aimed chiefly to describe the *kinds of rocks and their geographical distribution*, and did not note where, in any case, lines of stratification and of lithological distribution were, as is often true, not coördinated.* I have made observations toward the same end, and also widely, over Dutchess and Westchester Counties, New York. The work is still far from finished. But the discoveries by Mr. Dale at Poughkeepsie throw so much light on the general question at issue—the age of the Taconic schists, when they are connected with the facts already learned, that I here anticipate my fuller memoir by a brief statement of the facts and their bearing.

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* Dr. Percival was a very exact man in all his work. He made great numbers of observations on the dip of the crystalline schists of the State, but, unfortunately, did not publish them. They had a secondary importance with him because he believed that the different kinds of crystalline rocks were formed from an original crystallizing magma by successive segregations, and did not credit the ordinary views as to stratification and metamorphism. Lines of bedding very often strike across the boundaries of his lithological areas, showing that the latter as laid down on his map, while of interest, are no guide to the stratification, except in the case of the limestone areas and those of a few other formations of persistent lithological characters. It is due to Percival to say that his theory did not lead him to the slightest perversion of the stratigraphic or other facts before him, but only to a misappreciation of some of their bearings; and had the State of Connecticut been more generous to him in its allowance of time for the completion of the survey, and of money for the publication of his notes, there would have been little left for later geologists to do.

1. ON THE HUDSON RIVER AGE OF THE TACONIC SCHISTS.

(1.) The discovery, by Mr. A. WING, of Trenton fossils, *Trinucleus concentricus* and other species, in beds of the crystalline limestone formation of Vermont that directly adjoin and underlie conformably the slates of the north-and-south Taconic belt, has established the fact that these Vermont slates are of the age of the Upper Trenton or the Hudson River group; and the fact that this Taconic belt continues southward, in an uninterrupted line, into and through Western Massachusetts, constituting the Taconic Mountains (lying on the boundary between that State and New York), and the additional fact that the same great limestone formation follows the belt through its course and underlies, in a synclinal, its slates or schists—as the writer has shown, the limestone of the east side dipping under the mountains and becoming the limestone of Copake and Hillsdale on the west—affords scarcely less positive proof that these Berkshire Taconic slates also, the original typical Taconic slates of Emmons long supposed to be Cambrian or pre-Silurian, are of Hudson River age.

This conclusion loses nothing of its certainty in consequence of the fact of a change in the schists of the belt from argillaceous schists at the north (one source of the roofing-slate industry of Vermont), to hydromica, chloritic and garnetiferous mica schists, and staurolitic schists, toward the south extremity of the mountains; for the introduction of hydromica schists (formerly called *magnesian* and *talcose schists*) takes place in Vermont not far from the localities that afforded the fossils; and these hydromica schists continue the whole length of the belt, though more chloritic, more coarsely micaceous, and often garnetiferous, to the south. As to the synclinal of the Mt. Washington portion of the Taconic range in southwestern Massachusetts, Professor W. W. Mather, in a section on Plate 16 of his New York Geological Report (1843), across the mountains fifteen miles farther south, represents the limestone of Salisbury as dipping *westward* beneath the slates while those of the west dip eastward, as they do elsewhere on that side of the mountains. Further; my own recent observations in Northern Salisbury, within three miles of the Massachusetts line, confirm those which I made just north in Western Sheffield;

that the limestone along the eastern foot of the mountains (near or west of the nearest road to them) dips *westward*—the dip being found to be 45° to 60° to the west, with the strike between N. 3° E. and N. 3° W. (true).

(2.) The recent discovery, by T. Nelson Dale, Jr., of fossils of the Hudson River group in the slates or argillaceous schists of Poughkeepsie, on the Hudson River, (sustaining the early views of the New York geologists, Professor W. W. Mather and Professor James Hall,) affords another line of approach to the Taconic Mountains of Massachusetts, and presents further evidence of their Hudson River age. In the first place, the limestone belt which lies, as above remarked, at the western foot of these mountains along through Hillsdale and Copake, and which is the western side of the mountain synclinal, branches off from Copake south-southwest through middle and western Ancram, and extends along the whole course of the valley of Wappinger Creek to the Hudson River, which it reaches only four miles below Poughkeepsie, with a single interruption of less than three miles; and it is everywhere conformable to the argillaceous schists which border it on the east, including those of Poughkeepsie; and also with those on the west, except along a region of faulting near Bangall and Stissing Mountain (a range bordering the limestone area on the west between Stissingville and Pine Plains.) This continuation of the slates and limestone northeastward, from the Poughkeepsie region to the Copake, renders it highly probable that the same limestone formation which adjoins, and is conformable to, the Hudson River slates or schists of Poughkeepsie, adjoins, is conformable to, and underlies the schists of the Taconic Mountains.

The limestone of Wappinger Valley is the Barnegat limestone of Mather—so named from a locality on the Hudson, south of Poughkeepsie, where it is burnt for lime; and this geologist gives it the course here described, mentioning that it outcrops on the Hudson at the mouth of Wappinger Creek between Barnegat and New Hamburgh, and follows the river northeastward to Copake (not noting the break in it);* and he also states that it appears on the *west* side of the Hudson and stretches on to the south-southwest, passing within one mile of Newburgh, into the town of New Windsor, in which it ends, not far from the Archæan of the New Jersey Highlands, in a small body of water called Little Pond. The writer has examined the limestone at various points along the valley; and he has found the conformability to the slates, stated by Mather, to be very generally true. The limestone area is similar to the limestone region east of the Taconic Mountains in having large limonite beds, not only in Copake and farther north, but also in Central Ancram and beyond to the south; among them the Reynold's ore-pit, three to four miles southwest of the Weed ore-pit of Southern Copake, and the Morgan, a mile and a half farther south. Thus the observations accord well with the view that the limestone belt which borders conformably the Hudson River argillaceous schist of Poughkeepsie is the same that borders the Taconic schists in Copake and Hillsdale. If so, since the Copake and Hillsdale, or Western, belt of limestone dips under the Taconic Mountains and comes up, on the east, as the "Great Central belt" of the Green Mountain region, the Barnegat or Wappinger Valley limestone is only a southwestern extension of the great limestone formation that outcrops around Dorset, Rutland and Middlebury, Vermont. The occurrence of limonite beds along the junction between the schists and limestone, as a result of their alteration, in both the eastern and western belts, is an additional mark of general identity.

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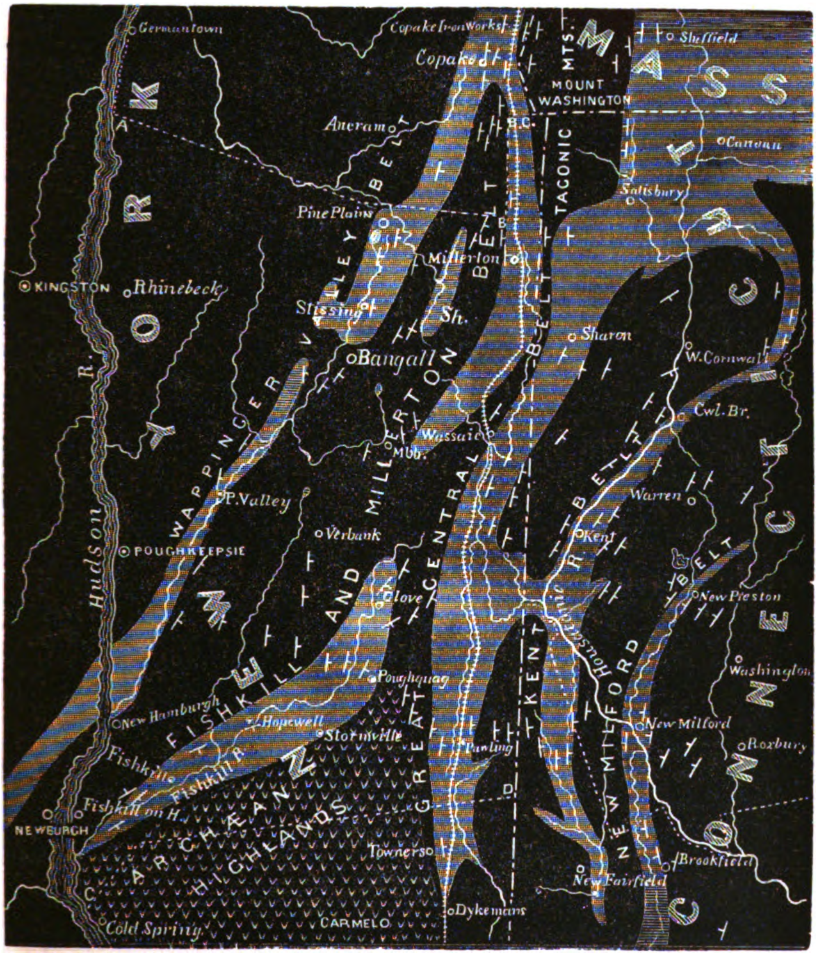
* Geol. Rep. 4to, 1843, pages 413 and 437. In the paragraph on p. 437 here referred to, there is some confusion as to the courses of the other Dutchess County limestone areas.

[On the accompanying map, representing a portion of Eastern New York, with also part of Western Connecticut and the southwest corner of Massachusetts, the general position of two Dutchess County limestone belts is shown, from their outcrops along the Hudson River to their junction with one another in the Copake limestone belt, west of the area of the Taconic Mountains. The map also gives the position of the southern part of the "Great Central" limestone belt of the Green Mountain region, as laid down by Percival on his geological map of Connecticut, from Sheffield in Massachusetts, and Canaan in Connecticut (where it has the width which characterizes it farther north in Berkshire and Vermont), through Salisbury and Sharon, and thence through Eastern New York, here gradually narrowing, to its end among contorted beds of micaceous gneiss eight miles south of Pawling, and just east and north of the Archæan Highlands. These areas, where broadest, include some intercalated beds of schist and isolated schist ridges. The map also gives the position of two eastern limestone belts in Connecticut, that of Kent and Cornwall, and that of Brookfield and New Milford. The T-like symbols over the map, indicate the strike and dip from my observations.]

(3.) Besides this stratigraphical evidence we now have *more positive evidence from the occurrence of Trenton fossils in the limestone of some parts of Wappinger Valley.*

Professor Mather makes the statement in his quarto New York Report (repeating it from his Annual Report of 1838), that in a bed of slaty limestone existing in the slates one-and-a-fourth to one-and-a-half miles north of Barnegat, "a few fossils were

Map of Dutchess and the adjoining Counties of Eastern New York, with a portion of Western Connecticut and Southwestern Massachusetts.



Dutchess County is included between the boundary lines AB B.C. on the north, and CD on the south. On the north is Columbia County, and on the south, Putnam. The Archæan Highlands of Putnam County are a continuation of those of Orange County, New York, and Sussex County, New Jersey. The light areas represent areas or belts of limestone. The notched line just west of the Connecticut boundary is the course of the Harlem Railroad. *B. C.*, Boston Corners; *Cwl. Br.*, Cornwall Bridge; *Mbb.*, Mabbittsville; *P. Valley*, Pleasant Valley; *Sh.*, Shekomeko Station, on the Dutchess and Connecticut railroad—the two streams in the adjoining limestone area being tributaries to Shekomeko Brook.

Scale, 1-10th of an inch to a mile.

found that have been recognized as belonging to the Trenton limestone."[*] The names of the species are not given. The Barnegat limestone is not far distant to the south and is the next adjoining stratum. The Poughkeepsie slates dip *beneath* the limestone, the dip being southeastward. But if the rocks are in folds and the limestone makes an *anticlinal*, it is an inferior bed notwithstanding the position.[†] In the Barnegat or Wappinger Valley limestone, which is a dark gray, semi-crystalline rock, Professor Mather found no distinct fossils. He states that his assistant, Professor C. Briggs, "in making his section from Poughkeepsie to Canaan in Connecticut, discovered faint traces of shells at a quarry a little south of Pleasant Valley on the bank of Wappinger's Creek; but they were too imperfect for determination. They were situated between the slaty layers, which have a dip to the south-southeast of 35° to 40°." Mather quotes also Professor Briggs as reporting that Mr. William Thorn of this place (Pleasant Valley) had informed him that "he had often seen shells in the lime rock, although they are rare."[‡]

Had Professor Mather himself visited that quarry half a mile southwest of Pleasant Valley (about seven miles northeast of Poughkeepsie), he would not have left the fossiliferous character of the limestone in doubt, and inserted discrediting remarks in his Report. Besides, Logan's unfortunate idea of the Quebec group extending over the region, and some other wrong geological inferences, would never have had birth. At a visit to the locality this spring, in order to ascertain the facts in the case (in which I was accompanied by Professor Wm. B. Dwight of Vassar College, Poughkeepsie) I found fossils abundant and distinct. Among them we observed at the time of our visit, remains of two or three species of *Crinoids*, *Cyathophylloid corals*, *Leptæna sericea*, *Orthis tricenaria*, *O. testudinaria*, *Orthoceras junceum*,[§] forms suggesting *Strophomena alternata* and fragments of *Trilobites*. What appeared to be the rounded pebbles of a conglomerate layer, proved to be worn specimens of a *Chætetes* ——? with columns not over 1-250th of an inch in diameter. The snow was deep over the country (so deep that our geological excursion was made "on runners," since either "on foot" or "on wheels" would have been attended with some difficulty), and hence a full examination of the locality could not then be made. It cannot be, for the same reason, at the present time (March 21), and I have left the region to be reported on further by Professor Dwight.

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[*] Page 401.

[†] Professor Mather calls the Barnegat limestone *Calciferous*, apparently because he had proved a limestone bed above it—that above referred to—to contain Trenton fossils; he could have had no other reason for it, for he says that he had no fossils from it.

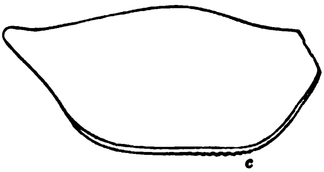
[‡] Page 410.

[§] The form, size, and distance between the septa, are the same as in this species.

Another locality of fossils in the Wappinger Valley limestone at Rochdale, four miles east of Poughkeepsie, had been visited by Professor Dwight the week before—he having been informed with regard to fossils there the day after he received my invitation to join me in the excursion—and it is not less prolific. Great surfaces are coverėd with the Crinoidal remains, and all the species observed at Pleasant Valley are found there; and, besides, a portion of an *Endoceras*, ten inches long and two inches wide at its larger end, and remains of large specimens of *Receptaculites*. I refer to the article following this for Professor Dwight's preliminary account of the fossils.

Previously, early in December (the day before the first snow-storm of the late snowy winter), I made a search for fossils at the northern end of the Wappinger Valley limestone, in eastern Ancram, just west of the extremity of Winchell's Mountain and not three miles distant from the Taconic Mountains, and found what I then and now believe to be the common Trenton species, *Orthis occidentalis*;* and with it there is another kind, of uncertain character, which may possibly be the Trenton *Strophomena alternata*. The specimen of the *Orthis* presents to view a section of the shell, having the size, form and thickness indicated in the accompanying figure. The thin shell is converted into white calcite (through the metamorphism) excepting in some parts an extremely thin exterior layer; and over a portion of the exterior (at *c*) there are sections of a few of the costæ. The hinge side of the shell is wanting in the specimen. A horizontal section made through the more convex (or ventral) valve was found to have the form which it should have if of the species here supposed; and so for the other valve. The evidence is therefore quite strong in favor of its being this common Trenton Brachiopod.

1.



The forms referred doubtingly to *Strophomena alternata* have the arcuated outline, shape and thickness, that would belong to sections of this arcuate shell. They are of white calcite and correspond to individuals one to two inches broad and diminishing mostly from a fourth to a sixteenth of an inch in thickness. Besides the sections, there are also broad concave surfaces like the inner surface of valves. No appearance of striation can be detected in connection with any of the forms.

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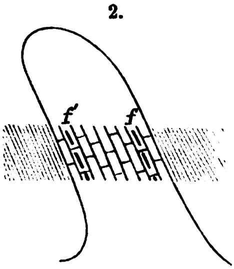
* The specimens were from a large freshly broken mass of limestone by the road side that was evidently derived from an outcrop near by.

I have been again over the Ancram region, but without finding other specimens—the limestone being much more crystalline than it is toward Poughkeepsie.

The fossils of Pleasant Valley and Rochdale, prove that the limestone of Wappinger Creek Valley contains a stratum of the age of the Trenton; and that of Ancram has the same bearing. The width of the part of the belt at the two former places is two-thirds to three-fourths of a mile; and since the bed containing the fossils is, at each of these localities, within 200 to 230 yards of the *eastern margin* of the limestone belt, it is probably one and the same bed. The lithological character of the rock sustains this. The *western margin* lies conformably against the Poughkeepsie "Hudson River" slate; and hence the western portion also must be Trenton. It follows then: *first*, that the belt is an anticlinal of limestone (as represented in the figure, *f*, toward the east side, being the observed fossiliferous bed); and, *secondly*, that the slate on the *east* of it is of Hudson River age, as well as that *west*. Further: these facts, and the concurring evidence from Ancram, where the lime-stone is essentially the Copake limestone, leave little doubt that Trenton beds continue northward to the very foot of the Taconic Mountains; and that the schists of the Taconic Mountains, like those of either side of the Wappinger Valley, including Winchell's Mountain, *are Hudson River in age.*

2.



The Wappinger Valley belt may have at centre a Chazy or other subjacent limestone stratum; and if so, the fact would only make more complete the identity of the Poughkeepsie and Vermont formations.

In the vicinity of Stissing Mountain there are quartzyte outcrops; and, if the rock is of the age of the Potsdam sandstone, the portion of the limestone next adjoining may be Calciferous. The mountain consists of fine-grained, gray gneiss, along with slate on the west, and at the southern end the gneiss contains minute zircons; I reserve the discussion of the age of the gneiss for another paper—the first draught of which was made nearly eight years since.

(4.) But this Wappinger Valley limestone is not the only southward extension of the Copake limestone. Another (see Map) extends from it southward by the western foot of the Taconic Mountains through Boston Corners and Millerton; and in the vicinity of the latter place it has its limonite beds. Thence it takes a south-by-west course through Western Amenia, and

Eastern Washington. It stops in the latter town just east of Mabbitsville. But six miles south, in the next town, Unionvale, it appears again in the valley of the Clove, and follows Fishkill Creek to its junction with the Hudson. At Poughquag, it has the extraordinary breadth of three miles, and it continues to have great width past the village of Old Fishkill; but it then narrows, becomes confined to the south side of the Fishkill Creek in Glenham, and is very narrow toward the mouth of the creek.* It evidently loses in breadth in this part because of its nearing the Archæan region of the Highlands, which is not half a mile distant; and its more western course from Poughquag to the Hudson has the same origin. The Hudson River slates border it conformably on the north. Limonite beds occur along this belt in Unionvale, where is the Clove ore bed, two on Sylvan Lake, and one in East Fishkill.

Through this Millerton-and-Fishkill belt of limestone there is hence a second connection between the Hudson River slates of the borders of the Hudson River region and the schists of the Taconic Mountains.

The limestone is throughout as decidedly crystalline as in the northern half of the Wappinger Valley belt (though never coarsely so); and hence fossils would be uncommon if occurring in it at all. In many places forms suggesting a fossil origin are to be met with.

Wherever the limestone contains seams of quartz such indications rarely occur, the most suggestive appearances being small and thin isolated bits of quartz, arcuate in section. Since the silicification, or the making of the siliceous seams, was carried forward by *hot* siliceous waters (not *cold*, as in the case of silicified shells in an unaltered limestone) during a time of metamorphism in which the limestone was crystallized and quartz veins were made in the slates or schists, fossils, if any were present, would naturally have been dissolved away. Almost the only chance for recognizable forms is in places where the limestone is without quartz, and the seams and spots it contains are of white calcite. One of this kind, which I observed in the limestone seven miles north of Millerton, near the base of the Taconic Mountains, seemed to be part of a valve of a ribbed Brachiopod, and others of like suggestiveness were met with in some of the limestone cuts between Hopewell and Fishkill. Such appearances favor the expectation that distinct fossils may yet be found in this belt. Three miles west of Hopewell I obtained specimens looking closely like the Wappinger Valley *Chætetes*, but with its structure lost.

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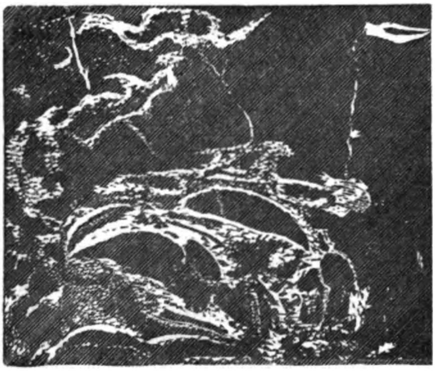
* I found the limestone outcropping at the village of Lithgow, and east of Mabbitsville (*Mbb.* on map), as stated by Mather. South of this, the country is high, the elevated region to the eastward (called farther south Chestnut Ridge) spreading over it, and having its rocks small in dip, with undulations, and with the limestone evidently concealed beneath. The limestone reappears where the valley opens again, along Clove Brook, and is thence continuous to the Hudson.

Between the Wappinger-Valley and Fishkill-and-Millerton belts, there are other outcrops of limestone.

One area, nearly six miles long, lies between the northern ends of these belts, in the Shekomeko Valley. (See the map.) Winchell's Mountain bounds it on the east, and Husted station is toward its northern extremity. The limestone is similar to that of the Fishkill-and-Millerton belt, but has in many parts a delicate bedding that shows the action of slowly moving water during its accumulation. The accompanying figure (from a photograph) represents, natural size, figures on a specimen of blue limestone, from a ledge near Shekomeko Station (*Sh.*), which are of white calcite and similar to those alluded to above as suggestive of Brachiopods. Another specimen contains a group of *black* curving surfaces, which are unquestionably of organic origin, and look like impressions of a few successive broken segments of a *Trilobite* 1¼ in. broad.

3.



Another area exists just below the Verbank railroad station, where two small hills of a badly rifted, quartz-seamed, gnarled limestone occur, which is various in strike, but mostly nearly north and south, and is without continuation at surface either north or south. A third occurs at Arthursburg, hardly eight miles south of Verbank. I learn from Professor Dwight, that a ledge, 1,800 feet wide occurs two miles southeast of Pleasant Valley. Mather mentions one between Redhook and Milan.

Over the country between the two Dutchess County limestone belts, the dip, excluding some local exceptions, is eastward (mostly between east-by-south and east-southeast) and the beds, as has been stated, are all conformable. It is true that the *cleavage* of slates is not always conformable to the stratification; but since over this region the lamination in them corresponds in all cases with the bedding of the many intervening limestone strata, the uncertainties which are thus introduced do not affect the above general statement as to conformability and eastward dip. In a supplement to this paper, the actual dips and courses observed, will be given.

Rocks.—The schists and limestone east of the Taconic Mountains are more crystalline than those *west*, and the crystalline character diminishes from these mountains *westward* toward the Hudson, just as it diminishes along their line northward toward Central Vermont. The rocks are mica schist and hydromica schist, and to the south micaceous gneiss, over the eastern part of Dutchess County; but, approaching Poughkeepsie, the schist in part fails even of the glossy luster, and becomes dull argillaceous and partly carbonaceous schist. North of Dutchess County, in Columbia County, argillaceous schist is the prevailing rock, and it is often carbonaceous in Ancram and part of Copake. The micaceous gneiss of the Taconic schist belt is well seen two miles west of Pawling; and here, against its eastern side, between it and the limestone, there lies a large limonite ore-bed. And this gneiss-like character continues to its extremity, south of Towner's, where, in a dry portion of a large marsh, north of Croton Lake, the limestone is exposed to view, alternating with coarse gneiss. In the slate ridge next west, the northern extremity of which is called Winchell's Mountain (west of Boston Corners and Millerton), the rock is argillyte, and hydromica schist, partly chloritic; but to the south, it becomes gradually coarser, being a mica schist on its eastern or more crystalline side, at Wassaic; and ten miles farther south, a decided mica schist on its western side, and still coarser on the east; and even gneissoid south of this.* Mather recognized the same changes, in this range of slate, stating it thus (Rep. N. Y. Geol., p. 433): "in its northern part, of slate and talcose and chloritic slates; the middle part, of mica slate; and the southern portion, of gneiss." The extremity of the "Great Central" limestone belt is in the area of Croton lake.†

The facts in Dutchess County thus show that argillaceous schist, hydromica schist, mica schist of garnetiferous, chloritic, staurolitic and other varieties, and micaceous gneiss, which are the occurring rocks of the so-called "Taconic system" or "Taconian," are here of one and the same age, and they leave little reason to doubt that they are, together, *of the age of the Hudson River Group.*

Quartzyte occurs adjoining the Archæan, southwest of Matteawan, three miles from the Hudson River—a locality pointed out to me by Mr. Charles M. Wolcott of Fishkill. The quartzyte was jointed and obscure in its bedding; but since a limonite deposit (usually situated in these regions, between conformable strata of schist or quartzyte and limestone) adjoins it, and the proprietor, Mr. Wolcott, found this one resting on beds approaching the quartzyte in character, it is very probable that the stratum is conformable with the limestone, whose outcrops are not far distant, and that it is of the age of the Potsdam sandstone. The adjoining portion of the limestone may hence prove to be Calciferous or Chazy. Quartzyte rests on the Archæan also at Poughquag, but in nearly horizontal beds (see this Journal, III, iii, 250, 1872) indicating a fault between it and the adjoining limestone. Mather mentions its occurrence also at Shenandoah.

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* According to a section by Prof. N. H. Winchell (received by the author from him in 1872) from the top of Winchell's Mountain eastward to Lakeville, seven miles, along a line ½ m. north of Millerton, the rock of Winchell's Mountain west of the summit is argillyte, and east of it mica schist; next east is the Millerton limestone nearly two miles wide; next, mica schist, of the same width, having, on the west a thin stratum of "compact, fibrous hornblende schist, somewhat micaceous" (as seen in a section on the Connecticut Western R. R.); and then, the limestone of Lakeville. The dip is stated to be north of east, except at Lakeville where there is a low anticlinal.

† It is rather probable that an outcrop exists two miles farther south, in the site of another pond south of Dykeman's, though none is in view. There is here a final termination of the valley by high Archæan hills.

At Glenham near Fishkill, a flesh-red, coarse granite-like stratum (or "bastard granite," as it has been called) lies between the limestone and the slate, conformable to both; and it is evidently one of the stratified deposits, as is shown by its conformable position, and its taking the color of the slate near the junction. The adjacent Archæan Highlands were the source of the coarse granitic sand of which it was made.

2. DEPENDENT RELATIONS OF THE TWO DUTCHESS COUNTY LIMESTONE BELTS AND TWO EASTERN BELTS IN CONNECTICUT.

The preceding map also represents, from Percival, two eastern belts of limestone in Connecticut, the *Kent* belt and the *New Milford* belt; and I may add that I have been over these regions pretty thoroughly, and can attest to Percival's correctness.

Viewing these belts and the three to the west together, and remembering that the Great Central belt is identified with the Green Mountains through Massachusetts and far into Vermont, it seems to be a safe conclusion that all are parts of one system; and that they owe their existence to a series of extensive cotemporaneously-made folds of the wide-spread Lower Silurian formation of the region. The New Milford and Kent belts are the *opposite sides of a synclinal;* for the schistose rocks between have, as I have found, a westward dip along the eastern portion, and an eastward dip along the western portion, as indicated by the symbols for the dip and strike on the map. The Great Central belt and the Kent belt *pass one into the other* in the vicinity of South Dover (see map), and also to the north in the eastern part of Canaan, and thus they are one.

Over the large gneiss area next west of Kent, the schistose rocks are, for the most part, conformable to the adjoining limestone belts—the strike about N. 20° E. along the southern half and on the eastern side of the northern half, and with N. 50° E. as the average near the Housatonic River, as if from a wrench in the mass. On the southern portion of the *east* side both north and south of Kent, and also along a large part of the *west* side, the rock adjoining the limestone is *quartzyte;* and next follows gneiss; *the quartzyte in several places is gneissoid, and graduates into the hard gneiss.* South of Sharon, the rock next to the quartzyte is *granulyte*, and there is a partial transition from one to the other. The quartzyte of the two sides of the area is, with little doubt, the same stratum, and probably the Potsdam sandstone; and in that case the conformable gneiss will correspond to inferior beds of the Primordial, and the adjoining portion of the limestone belts may be Calciferous; further, the strata make an anticlinal over the intervening area of gneiss. This area includes some unconformable ledges, both in the northern and southern half, in which occur chondroditic limestone, syenyte, beds of titaniferous magnetite, and hard gneisses, which may be Archæan; and if so, they are outliers of the large Archæan area of the Highlands which exists to the southwest.

3. INFLUENCE OF THE LIMESTONE BELTS ON THE FEATURES OF THE SURFACE.

Limestone being a brittle rock, the region of flexures, whatever the thickness of the overlying mass, would have been profoundly fractured, especially in anticlinals; and being also a soft rock, it would have been easily carried away by denuding agencies. The limestone belts are the chief courses, as Percival pointed out, of all the greater valleys and streams of the limestone region; and in these valleys, as I have found, the underdipping side of the limestone is generally the bold, precipitous side, owing to the undermining which it has occasioned. This is so generally true that vertical fronts in these metamorphic regions (and I may add in Westchester County as well as farther north and northeast) are pretty sure evidence of outcropping limestone below.

4. CONCLUSIONS.

1. The Taconic schists are, according to the evidence, of the age of the Hudson River group.

2. The conformability in the rocks between the eastern of the Connecticut belts and the Hudson, being established by observation, the five limestone belts are plainly, as above suggested, but five outcropping bands of the Lower Silurian limestone formations, brought to the surface by a series of flexures.

3. The disturbance which upturned and crystallized the limestones and other conformable formations in the Green Mountain area, through Vermont and Massachusetts, extended south over

certainly a large part of Western Connecticut, and over Eastern New York at least to the Hudson.

That hard gneisses and mica schists are among the included formations does not, in any way, affect the evidence or the conclusions here deduced.

These conclusions coincide partly with those reached by Professor Mather, as stated on pages 438, 464, and 628 of his Report, namely: (1) That the limestone of Eastern New York and the Green Mountain region, including that of Westchester County down to New York Island, is of the Trenton or Calciferous (Canadian) periods; (2) that the slates, gneiss, mica schist and other rocks, directly associated with the limestone in Massachusetts and elsewhere, are of the Hudson River age; (3) that the quartzyte is of the age of the Potsdam; (4) that the making of the Green Mountains and the metamorphism of Western New England, took place at the close of the Lower Silurian. Proposition (1) appears to me to be established, if we admit, in addition, that the limestone may in some places be in part Primordial, and leave out of consideration, for the present, that of Westchester County. Proposition (2) is pretty well demonstrated as far as the slates or schists of the Taconic Range are concerned; but,—as I present in the second of my articles on Berkshire geology—we cannot say now of the gneiss and mica schist ridges to the east of the Taconic range more than this, that they are Lower Silurian; and among the gneisses are those also of local Archæan areas. Proposition (3) is almost certainly true for part of the quartzyte, but it is not yet safe to say this of all. Proposition (4) has strong support in all the observations which I have made in the Green Mountain region.

Professor Mather has a separate chapter on "Primary rocks" under which head he includes the rocks of the Highlands, and, with these, the gneisses and mica schists of Westchester County and New York Island. The distribution of the limestone areas of Westchester County with reference to one another and those of Connecticut, and their stratigraphical relations to the gneisses and mica schists associated with them, are a basis of evidence on this question of age, and the facts I have observed and mapped I shall present in a following number of this Journal.

The nature and stratification of the schistose rocks intervening between the Connecticut limestone belts I have studied with some detail, and I propose, after further investigations, and the removal of some doubts as to the limits of the included Archæan, to make these also the subject of another paper.

ART. XLVII.—*On some recent Explorations in the Wappinger Valley Limestone of Dutchess County, New York;* by Professor WM. B. DWIGHT, of Vassar College, Poughkeepsie, N. Y.

MY attention was called to the possible fossiliferous character of the Wappinger Valley limestone by an invitation from Professor Dana to join him in examinations at Pleasant Valley, of a reported locality of fossils doubtingly mentioned by Professor Mather.* In order to further the object in view, I made enquiries with regard to another reputed locality, at Rochdale, and the next day I was gratified to find the limestone there abounding in fossils. Since the excursion to this place and Pleasant Valley with Professor Dana, which took place a few days later, I have continued my search in the Barnegat or Wappinger Creek limestone, he leaving the field to me, and have discovered still other localities; and it is the object of this paper to mention the facts thus far ascertained.

As my acquaintance with this part of the country has been but a brief one, and as my researches have been conducted in the scanty hours that could be snatched from my collegiate work during the last four weeks, the results which I here put on record should be regarded as merely preliminary to the more careful investigations of this interesting formation which I hope to make.

The first locality which I examined was one at Rochdale, above alluded to, where objects of peculiar forms had been reported to have been found, though there is no evidence of any scientific examination. It is situated four miles northeast of Poughkeepsie, on the premises of Mr. Henry Titus.† The limestone here has a dip of 60° southeasterly, with a strike of N. 36° E. (true). The examination, though short, afforded me abundant evidence of fossils, and some determinable species, as follows:—*Leptæna sericea*, an internal cast of the ventral valve, showing the characteristic form of the callosities for visceral attachment, and the striæ in reverse; two specimens of *Orthis tricenaria;* small encrinal columns in countless numbers; a spiral shell, two and a half centimeters in diameter, exhibited only in section, imbedded in the rock.

Besides these, there are many specimens of a species of *Receptaculites.* Groups of cylindrical or club-shaped columns, half an inch or so long, project inward, somewhat radially, from a hollow but rather firm shell of irregular form which varies much in size; they consist of the limestone and are evidently the fillings of the tubes of Receptaculites. They are so imbedded in the rock that I have not yet been able to detach any for special study, as I propose soon to do.

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* N. Y. Geol. Report, 1843.

† I take this occasion to acknowledge my indebtedness to Professor T. J. Backus, of Vassar College, for information of this locality, and assistance in pointing out fossils, and to Messrs. Henry and Richard Titus, proprietors of the Rochdale woolen mills, for courteous coöperation in the work.

My second trip to this locality, a week later, was made in company with Professor Dana. I found, at this time, another distinct specimen of *Leptæna sericea*, one *Escharopora recta*, one *Ptilodictya acuta*, a pygidium of a trilobite, several specimens of *Orthis tricenaria*, an *Orthis pectinella*, one *Endoceras* twenty or twenty-five centimeters long, one small *Orthoceras*, two of *Orthis testudinaria*, and some *Chætetes* of minute columnar structure.

On the same occasion we visited a quarry on Wappinger Creek, about half a mile below Pleasant Valley, where Mather reported faint traces of shells to have been found, "too imperfect for identification." We found abundant evidence of the fossiliferous character of the rock, the fossils being generally similar to those at Rochdale. In a subsequent examination of my specimens here collected, I obtained one well-defined specimen, and several small fragments, of *Strophomena alternata*,—showing its characteristic arrangement of striæ; also, very abundantly, the Chætetes found at Rochdale, from two inches to one-quarter or less in diameter. The large specimens are sometimes semi-globular, and suggest *Chætetes lycoperdon*, but for the microscopic tenuity of the columns; but other specimens are pyriform, and I am not certain as to the normal shape. The diameter of the columns is less than 1-200th of an inch. As it appears to be new, I propose for it the name *Ch. tenuissima*.

My subsequent trips have been taken alone. On the farm of Mr. Brittenberger, two miles southeast of Pleasant Valley, east of Wappinger Creek, I found a second and parallel outcrop of limestone, 1800 feet wide, separated by slate from the main body of the Wappinger Valley belt. The rock is here filled with limestone pebbles of various sizes and lighter in color than the mass. Many of these may have been organic, and very likely corals, but crystallization has so obliterated the structure that if detected at all, it must be by microscopic examination. There was one specimen which is probably an encrinal column about seven centimeters long, and seven millimeters wide.

I have made examinations at Salt Point, on Wappinger Creek, at the junction of Salt Point Creek, ten and a half miles northeast from Poughkeepsie, and also at a number of places between Salt Point and Pleasant Valley. At Salt Point the limestone has a width of 2200 feet, and it is about that width, or somewhat wider, toward Pleasant Valley. It is mostly on the west side of the creek, and for a distance of four miles south of Salt Point, it varies from the greater part of the outcrop by having a westerly dip of 70° to 85°, the strike averaging about N. 26 E. (true). Thus far I have succeeded in finding here only the spiral shell met with at Rochdale, and three small but very distinct Orthocerata. This spiral shell occurs in particular layers extending through this entire section; some specimens appear to be scattered through the rock, but in these layers they exist in immense numbers. On a single surface of 50 square centimeters, which I broke out of the solid rock, there are more than twenty distinct specimens. This is beyond the average, but the specimens are often so numerous as to crowd upon each other.

The best localities I have discovered are in two quarries of F. B. Wallace, on Wappinger's Creek, respectively one and one-quarter and one and one-half miles below Salt Point; and in two cuts on the Poughkeepsie, Hartford and Boston Railroad track, two miles north of Pleasant Valley. Generally only the simple spiral line is preserved in section. In many cases, however, more or less of the tube of the whorls remains, quite hollow, but its surface too granular to allow the preservation of any marking. The spire in many cases shows a depression of about two millimeters below the surface of the outer whorl. In most cases no septa are visible, but among some fine specimens, from the lower Wallace quarry, several show distinct internal, transverse septa. One, which is unusually good and sharply defined, shows as many as fifteen septa in its four whorls in good state of preservation. I have not yet been able to make out clearly a siphuncle. Most of the specimens exhibit four whorls, and some traces of a fifth; the rate of expansion in the width increases gradually, the spirals being closely coiled. A few of these spiral shells are loosely coiled; and some, whose whorls present an angular edge, are of essentially different character from the others. From present appearances I should judge most of these shells to be those of *Trocholites*, but I hope soon to secure more decisive specimens.

At Manchester, three miles east of Poughkeepsie, no organic remains appeared, except a beautiful fucoid, which had much resemblance to *Buthotrephis gracilis*, and covered a large slab of rock.

In a visit to an outcrop on the Hudson River, one and one-half to two miles south of Milton Ferry, I discovered no fossils except a good specimen of *Leptæna sericea*, in the rock quarried from the limestone near where it borders on the shale that lies on its north side.

The results in fossils, of my examinations, the specimens of which were taken in every instance from the solid rock in place, may be summed up as follows:—

FROM ROCHDALE.

**Orthis tricenaria*; several.
**O. pectinella*; one.
**Leptæna sericea*; two.
**Escharopora recta*; one.
**Ptilodictya acuta*; one.
Caudal shield of small trilobite, probably *Asaphus vetustus*; one.
Endoceras (probably *proteiforme*); one.
Orthoceras not well defined; one.
Spiral univalves; several.
Chætetes, named above *Ch. tenuissima*; many.
Encrinal columns; exceedingly numerous.
Receptaculites; numerous.

FROM PLEASANT VALLEY.

**Orthis tricenaria*; several.
**O. pectinella*; one.
**O. testudinaria*; two.
**Leptæna sericea*; one.
**Strophomena alternata*; one or more.
Chætetes tenuissima; very common.
Encrinal columns; abundant.
Bellerophon?; one.
Undetermined corals; several.

BETWEEN SALT POINT AND PLEASANT VALLEY.

Trocholites?; exceedingly numerous.

Oncoceras constrictum?; one specimen, two centimeters in length and same in width.

Orthocerata; one, three centimeters long, with twelve septa; one, about a centimeter long, with five septa.

MANCHESTER.

Fucoids (*Buthotrephis gracilis?*); one.

Besides other conclusions from these researches, the following may be safely drawn:—

1. The "Barnegat limestone," contrary to views hitherto presented, is a highly fossiliferous formation, though on account of alteration, fossiliferous localities are rare compared with the exposure of rock.

2. The fossils are apparently those of the Trenton limestone, and therefore immediately underlie the adjoining shales which are now referred to the Hudson River group.

3. In the presence of the Chætetes of delicate structure, and of the layers thickly packed with spiral shells, the limestone appears to differ from that of any other known region of this formation.

Vassar College, Poughkeepsie, N. Y., April 7, 1879.

* Clearly defined as to specific character.

ART. XLVIII.—*Observations on the Planet discovered March 21st;* by C. H. F. PETERS. (From a letter to the editors dated Litchfield Observatory of Hamilton College, Clinton, N. Y., April 2d, 1879.)

I TAKE pleasure in communicating the following observations on a planet discovered on March 21st, the only ones the bad weather has permitted me to make.

1879.	H. C. mean t.	α (194)	δ (194)	No. of comp.
March 21	$14^h 15^m 47^s$	$12^h 12^m\ 3{\cdot}91^s$	$+\ 9^\circ 26' 30''{\cdot}2$	20
" 31	9 23 12	12 4 20·07	+11 1 3·9	12
April 1	9 11 13	12 3 34·63	+11 10 1·6	10

The planet is bright eleventh magnitude. On the same evening I found still another planet, 10th magnitude, and observed it;

March 21.
$11^h\ 32^m\ 21^s$ m. t. $\alpha = 11^h\ 58^m\ 45^s{\cdot}49$; $\delta = +9^\circ\ 18'\ 2''{\cdot}8$ (16 comp.)

As my computations from the elements (the Berlin ephemerides have not yet arrived) did not indicate any of the older planets in that place, I had reason to believe this one too a new one, and accordingly gave public notice of it. Professor Foerster, however, remarks that this is *Leto* (68). And indeed, I find now, that in the elements of *Leto* given in the Berlin Jahrbuch there is an error of print made in 1877, and perpetuated through the later volumes until 1880. The epoch printed there, 1874, should read instead 1864.

ART. XLIX.—*Note on the Stratigraphy of the Huronian Series of Northern Wisconsin; and on the Equivalency of the Huronian of the Marquette and Penokee Districts;* by R. D. IRVING.

IN the number of this Journal for September, 1876, Major T. B. Brooks has given, in a scheme of equivalency for the strata of the different Huronian districts in the neighborhood of Lake Superior, a synopsis of the Huronian section on Bad River, Northern Wisconsin, which is quite erroneous. The error has arisen chiefly from the failure to recognize the existence of a very important break in the strata—which break has indeed given the river an opportunity to cut its way through the Penokee range—and also from the difficulty in marking the line between the two great and totally distinct series, the Huronian, and Keweenawan or Copper-bearing series. Major Brooks's section is professedly a rough one only.

I have myself recently completed a study of my field results over the Huronian belt of this part of Wisconsin, as also of over one hundred thin sections of the rock specimens gathered, and have made a section which I think may be regarded as final. A synopsis of this is given below, as it will appear in vol. iv of the Wisconsin reports. I should say here that in beginning my lithological work on the Huronian of this region, I was aided by a detailed microscopic description of nine selected specimens furnished by Mr. A. A. Julien. In the year that has elapsed since then I have familiarized myself with this (to me) new, and all-important method of investigation, and have examined sections from nearly every ledge of importance within the Huronian area.

Synopsis of the Stratigraphy of the Huronian of the Penokee Region, Wisconsin.

LAURENTIAN.

Chloritic hornblende-gneiss and pink quartzose granite.

HURONIAN.

(Non-conformable with the Laurentian.)

Formation.			Average thickness.
I.	Tremolitic (Julien) crystalline *limestone*		90 ft.
II.	(A) Arenaceous white *quartzite*, often brecciated	35 ft.	
	(B) Magnetitic quartz-schist..	5 ft.	40 ft.
III.	*Siliceous slaty schists;* including quartzite, "argillitic" mica schist, and novaculite; all having much quartz, and none ever showing any amorphous material		410 ft.
IV.	*Magnetic belt*; including (*a*) banded magnetic quartzite—gray to red quartzite, free from, or lean in iron oxides, banded with seams, from a fraction of an inch to several inches in width, of pure black granular magnetite only rarely mingled with the specular oxide; (*b*) magnetitic quartzite—the magnetite in very varying proportions, pretty well scattered throughout, and mingled with the specular oxide in proportions varying from nothing to a predominating quantity; (*c*) magnetitic quartz slate, the magnetite pervading the whole, and mingled with the specular oxide, as before; (*d*) slate like (*c*) but largely charged with tremolite or actinolite; (*e*) arenaceous to compact and flaky quartzite, free or nearly so from iron oxides; (*f*) thin-laminated, soft black magnetitic slate; (*g*) hematitic quartzite, the iron oxide the red variety; (*h*) garnetiferous actinolite schist, or eclogite; (*i*) diorite, which is restricted to the western end of the Huronian belt. Kinds (*a*) to (*d*) all carry much pyrolusite, or other manganese oxide. These varieties have no persistent stratigraphical arrangement, and are named here in order of relative abundance. Total thickness about		780 ft.

Formation.	Average thickness.
V. *Black feldspathic slate;* consisting of orthoclase grains imbedded in a paste of biotite, pyrite, limonite (Julien) and carbon	180 ft.
VI. Unknown, always drift-covered	880 ft.
VII. Dark gray to black, aphanitic *mica-slate*, having a wholly crystalline base of quartz and orthoclase, with disseminated biotite scales	120 ft.
VIII. Unknown, but probably in large part the same as VII	290 ft.
IX. Chloritic, pyritiferous, massive *diorite* (Julien)	150 ft.
X. Black, aphanitic *mica-slate*, like VII	25 ft.
XI. Covered, but probably black mica-slate	280 ft.
XII. *Black mica-slate;* aphanitic; at times chiastolitic (Julien)	225 ft.
XIII. Chloritic *diorite-schist*	35 ft.
XIV. *Black mica-slate*, like XII, often chiastolitic	375 ft.
XV to XVIII. Alternations of black *mica-slates*, with *quartzites* and quartz-schists	675 ft.
XIX. *Greenstone-schist;* aphanitic; the hornblende and plagioclase much altered	260 ft.
XX. Covered; but probably like XXI	525 ft.
XXI. *Mica schist;* from aphanitic to medium-grained; including bands of light-gray quartz-schist, the mica becoming subordinate; all varieties having a background of quartz; the mica wholly biotite; penetrated by veins and masses of very coarse, pink to brick-red biotite granite; total seen on Bad River	4,960 ft.
Total thickness of the Huronian in the Bad River section	10,300 ft.
Add higher layers seen farther east; same as XXII	2,500 ft.
Total	12,800 ft.

KEWEENAWAN.

(Non-conformable with the Huronian.)

Very coarse to fine-grained gabbro, including granite veins and masses.

The Bad River section does not show the entire thickness of the Huronian, for the reason that the overlying gabbros of the Keweenawan Series cut diagonally across the Huronian. Seven miles west of Bad River the whole thickness of strata between the Laurentian gneiss, and Keweenawan gabbro, does not exceed 2,500 feet, while at the same distance eastward it is over 12,000 feet.

Equivalency of the Huronian systems of the Marquette and Penokee Districts.—There can be little doubt that the Huronian basin of Marquette was once directly continuous with that in which the Penokee rocks were deposited; there are, indeed, no facts yet on record going to show that the two rock-systems are not at the present time directly connected, though at surface the connection is obscured by the overlying horizontal Potsdam sandstone. Pumpelly and Brooks* have carried the Penokee belt uninterruptedly eastward as far as Lake Gogebic, where a deep depression, made by ancient erosion, occupied now by the horizontal sandstone, terminates the range abruptly. From here to the westernmost known portion of the Marquette Huronian is a distance of less than forty miles.

In the Marquette region Major Brooks has made out with great care and skill a succession of beds which he numbers from V to XIX. That essentially the same succession exists in the Penokee region, there can be little doubt. An attempt to make out a scheme of equivalency for basins always disconnected, based on lithology alone, would, beyond doubt, be but time wasted. In the present case, however, the two districts are really continuous, and many of the layers in the two regions so very constant in their characters, that there can be no valid objection to the attempt. It is undoubtedly true that it is very easy to make many mistakes in such a scheme, owing to the dying out of certain layers, and the variations along the line of strike of some member of the series, which, if not originally present, may have been produced by the partial process of metamorphism to which the whole Huronian system has been subjected. No scheme of equivalency can then be regarded as of any value, that is not based upon those few grand features of the stratigraphy, which are shown to be quite constant. The prominent facts in this connection, that have pressed themselves upon me while studying over my field-results in connection with the reports and typical collection of the Michigan survey, are here given. Major Brooks, whose wide experience in the several Huronian regions of the northwest, and whose skill in Huronian stratigraphy, are well known is, I believe, preparing a complete presentation of the whole subject of the equivalency of the strata of the various districts. The following are offered as suggestions toward the fuller treatment of the subject.

In Wisconsin we find at the base of the series a great bed (III) of light-colored quartzose slates and schists, over 400 feet in thickness, with characters so pronounced that it has been traced uninterruptedly for over fifty miles. The rocks of this layer vary from schistose vitreous quartzites, to argillitic mica-schists, while subordinate to it are the two lower members, the white arenaceous quartzite (II) and tremolitic crystalline limestone (III). Now in the Marquette region the base of the series is a great bed of quartzite (V), including argillitic schists, and limestones, both quite indistinguishable in hand specimens from the Wisconsin rocks. From the descriptions in the Michigan reports this layer is evidently no less prominent and persistent than No. III of our series. It appears evident that the two are directly equivalent.

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* Geological Survey of Michigan, vol. i, p. 183 of Report on Iron Rocks, and p. 1, of Report on Copper Rocks.

Above the siliceous slates in the Penokee system we find a great belt (IV) of magnetitic schists, of the several varieties above indicated, which is unquestionably continuous from Lake Nemakagon in township 44, range 6, west; eastward, nearly to Lake Gogebic, a distance of over eighty miles. In Michigan a succession of layers of strictly similar rocks—both macroscopically and microscopically—overlies the great "Lower Quartzite." In Michigan there are intercalated diorite bands. In Wisconsin these are known only toward the western portion of the belt, where they are, however, very prominent. The peculiar garnetiferous rock of the Penokee section has its exact equivalent in the Michigan magnetic belts, while numerous other peculiar details are the same in the two regions. I should then regard the Penokee magnetic belt as equivalent to Nos. VI to XI of Major Brooks' Marquette series.

Immediately above the magnetic belt (IV) of the Penokee system, or separated from it by a band of black slate (V), which is not known to be sufficiently persistent to deserve consideration in the present connection, is always a covered space without exposure, corresponding to nearly 900 feet in thickness of layers (VI). This would appear to be the equivalent of the belt including the rich ores of Michigan (XIII and XIV), a point of some practical interest.

Above this blank space we find the prevailing rock for a thickness of over 2,000 feet to be a black aphanitic mica slate, which includes, however, bands of quartzite, and thinner ones of diorite, besides which there are blank spaces, the nature of whose underlying rock is a matter of conjecture (VII to XVIII). The black slates and interstratified quartzites are known at points along a belt over twenty miles in length. The equivalents of these members, in the Marquette region, appear to lie from XIV to XVIII of Major Brooks's scheme, where we have quartzite and true clay slate, besides brown to black carbonaceous slates, often distinctly micaceous.

Forming the uppermost members of the Penokee system, we find a great development of mica (biotite) schists, equaling in thickness all of the lower members of the series, and including dark gray, aphanitic kinds, quite coarse, gneiss-like kinds, besides highly quartzose kinds. It is certainly a striking fact, that in the Marquette region the uppermost member (XIX), a mica schist, is the thickest of the whole series, covering often a width, according to the Michigan maps, of over a mile.

The granites which Major Brooks places in his scheme as the youngest of the Penokee Huronian (see this Journal for September, 1876) are merely intrusive patches and veins of small size and area, cutting both the upper mica schists of the Huronian, and the lower gabbros of the Keweenawan system. The gabbros are placed unhesitatingly with the Keweenawan, for the following principal reasons: (1) their general mineral composition allies them closely with the typical diabases of the Keweenaw series while contrasting them with the hornblendic Huronian; (2) when followed along the general trend of the formation, they are found giving place to typical Keweenawan diabase and diabase amygdaloid; (3) similar gabbro occurs interstratified with the undoubted Keweenawan rocks; (4) the gabbro belt cuts diagonally across the Huronian, which it narrows in places to less than one-third the full thickness, thus proving a distinct non-conformity. These gabbros are regarded as of igneous origin, having been one of the first of the great flows of the Keweenaw system, and laid down upon the slightly disturbed Huronian beds.

University of Wisconsin, Dec. 31st, 1878.

ART. L.—*On the Composition of the Cymatolite from Goshen, Mass.*; by A. A. JULIEN.

A MINERAL, pseudomorphous after spodumene, occurs in granite veins of Hampshire County, Mass., which appears to be that first found by Shepard, and by him called cymatolite. The variety at Goshen was analyzed by Burton, and, on the ground of his results, has been assigned to piblite. A specimen, identical in physical characters with the mineral of Shepard, has yielded me the following composition:

		Oxygen.
Water	2·58	2·29
Nitrogenous organic matter	·43	
Potash	8·38	1·42
Soda	2·57	·66
Lithia	·09	·05
Lime	·48	·14
Magnesia	·75	·30
Manganous oxide	·18	·04
Ferric oxide	1·66	·49
Alumina	24·38	11·38
Silica	58·11	30·99
	99·61	

These new results, corresponding by the old system to the formula

$$(\tfrac{1}{3}(\tfrac{1}{2}\dot{H}+\tfrac{1}{2}\dot{K}\ .\ \dot{N}a)^3+\tfrac{2}{3}\dddot{Al})\ddot{Si}^3,$$

induced me to propose a new name, *Aglaite* (Engineering and Mining Journal, April 7, 1877), but I have since inclined to the belief that the material is the same as that first studied by Shepard and Burton. It is therefore now presented as an independent species, under the original name, cymatolite, but it seems worth while to retain the name aglaite for application to the peculiarly brilliant and micaceous variety found at Goshen. In the coming volume of the Annals of the New York Academy of Sciences, I shall give a full discussion of the composition of this mineral, and of its interesting association with spodumene, killinite, œrstedite, autunite, etc.

Art. LI.—*The relations of the Volumes of Solutions of Hydrated Salts to their Water of Composition;* by Richmond J. Southworth, M.D.

The object of the experiments, the result of which is stated in the accompanying table, was to test this

Theorem: If a hydrated salt be dissolved in a given volume of water, the volume of the solution will exceed the original volume of the water by a bulk equal to the bulk of saline water contained in the salt dissolved.

The expression *saline water* is used here to signify all the molecules of water contained in the salts, whether they exist in combination as bases, or as water of crystallization. First, the weight in grams of the salt used that contained one cubic centimeter of water in its composition was determined by dividing the atomic weight of the salt by the atomic weight of its saline water, both weights being expressed in grams, the quotient gave the weight, having one cubic centimeter of saline water. As an example: Ferrous sulphate ($FeSO_4$, $7H_2O$) has an atomic weight of 278. Its 7 molecules of saline water have an atomic weight of 126. $\frac{278}{126}$ grams=2·206 the weight of this salt having one cubic centimeter of water in its composition.

Second: The quantity of salt determined by this method to contain one cubic centimeter of saline water was weighed to the nearest centigram, and then dissolved in 90 c.c. of water in a graduated tube of 100 c.c. capacity divided in one-half cubic centimeters. For instance, 2·20 grams of $FeSO_4$, $7H_2O$, were dissolved in 90 c.c. of water at the temperature of 15·5° Centigrade when the volume of the solution equalled 91 c.c.: 2·20 grams more of the salt were added to this solution, and the volume rose to 92 c.c. This process was continued till 22·06 grams of the salt, containing 10 c.c. H_2O, were dissolved in 90 c.c. of water, when the volume of the solution reached 100 c.c. In each of the steps, and in the final result, this experiment agreed with the theorem. This method was pursued where the first experiment with a salt showed a close agreement with the theorem. In those cases where there was a disagreement between the calculated volume and the observed volume of the solution, the weight of salt required to raise the volume of the solution one cubic centimeter was determined by direct experiment. For instance, barium chloride, with the formula ($BaCl_2.2H_2O$) by calculation contained one cubic centimeter of H_2O in 6·777 grams, but the quantity required to raise the volume of the solution one cubic centimeter was 3·89 grams. If the specimen of barium chloride used contained $4H_2O$, the experiment would give a result agreeing with the terms of the theorem.

Salt used.	By calculation.	By experiment.
$Na_2CO_3.10H_2O$	1·588	1·59
$Na_2SO_4.10H_2O$	1·788	1·63
$Na_2SO_4.H_2SO_4.3H_2O$	4·083	3·25
$Na_2O2B_2O_3.10H_2O$	2·122	2·12
$Na_2HPO_4.12H_2O$	1·591	1·59
$BaCl_2.2H_2O$	6·777	3·89
$SrCl_2.6H_2O$	2·468	2·47
$MgSO_4.7H_2O$	1·954	1·95
$ZnSO_4.7H_2O$	2·277	2·28
$NiSO_4.7H_2O$	2·228	2·23
$FeSO_4.7H_2O$	2·206	2·2
$CuSO_4.5H_2O$	2·771	2·77
$Al_2(SO_4)_3.18H_2O$	2·058	2·06
$AlK(SO_4)_2.12H_2O$	2·196	2·2
$AlNH_4(SO_4)_2.12H_2O$	2·099	2·1
$CrK(SO_4)_2.12H_2O$	2·31	2·31

The first column of the table gives the formulæ of the salts according to the last American edition of Fownes's Chemistry. The second column gives the weight in grams that contains one cubic centimeter of saline water, according to the formula. The third column gives the weight in grams found by experiment to increase the volume of the solution one cubic centimeter. An examination of the table will show a close agreement between the results of calculation and experimentation, with the exception of barium chloride, which has been referred to, and the acid sodium sulphate. The disagreement between the calculation and observation in this instance may possibly be explained by the salt decomposing in the act of dissolving, separating into sodium sulphate, which is dissolved, and hydrogen sulphate which unites with the water. This would agree with the strong acid reaction of the solution.

So far as the salts used in these experiments are concerned, the theorem stands the test of experiment, and is demonstrated to be true. In explanation of the changes that occur when a hydrated salt is dissolved in pure water, it may be assumed that the salt is decomposed, separating into an anhydrous portion and saline water, the former going into solution and the latter uniting with the solvent water, increasing its volume.

Yonkers, N. Y., Jan. 31st, 1879.

ART. LII.—*Analysis of the Tetrahedrite from Huallanca, Peru*; by W. J. COMSTOCK. Contributions from the Laboratory of the Sheffield Scientific School, No. LV.

IN this Journal for April, 1878, there is given a short extract from an article in the London Mining Journal by Mr. Henry Sewell, F.R.G.S., describing the mineral caves of Huallanca, Peru. Mr. Sewell states that these silver-producing caves are situated upon the eastern flank of the Peruvian Andes at an altitude of 14,700 feet above the sea, and 4000 feet above the town of Huallanca. The mass of the argentiferous ores consists of the mineral tetrahedrite; these ores contain about 800 ounces of silver to the ton. The mineral is in part obtained from huge cavities, some of them twenty-five or thirty feet long, and as much deep. Mr. Sewell describes the crystals as occurring in such abundance on the walls of these caves, that "millions" of them are destroyed by the picks of the miners.

Some specimens from this locality were presented to the Yale College Museum by Mr. Sewell; the crystals are large and brilliant and in one case have a length of about two inches. They have the usual characteristic tetrahedral form. I have analyzed a portion of one of the crystals, and have obtained the following results: Specific gravity =4·7.

	I.	II.	Mean.
S	26·69	26·79	26·74
Sb	9·08	9·04	9·06
As	13·35	13·62	13·49
Ag	3·95	3·77	3·86
Cu	39·01	39·16	39·09
Fe	5·46	....	5·46
Zn	2·14	....	2·14
	99·68		99·84

I give below the amount of sulphur required to combine with each of the metals and also the atomic ratio.

Sulphur calculation.	
Sb	3·56
As	8·57
Ag	·57
Cu	9·87
Fe	3·12
Zn	1·06
	26·75

Atomic ratio.		
S	·8356	·8356
Sb	·0743	·2528
As	·1785	
Ag_2	·0179	·4567
Cu_2	·3083	
Fe	·0975	
Zn	·0330	

From the above is obtained the ratio

$$\cdot2528\ R_2S_3 + \cdot9134\ RS, \quad \text{or} \quad R_2S_3 + 3\cdot6\ RS.$$

The method employed in the analyses was that of H. Rose, except in the determination of the arsenic. On account of the difficulty in weighing magnesium ammonium arseniate, after separating by means of magnesia mixture and alcohol the precipitate was dissolved in dilute hydrochloric acid, reduced by sulphurous acid, the excess of the latter was evaporated off, and the arsenic precipitated and weighed as sulphide. A slight amount of free sulphur was dissolved out by carbon-disulphide.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Determination of Fusing Points.*—Commonly fusing points are determined by placing a fragment of the substance in a thin glass tube attached to the bulb of the thermometer, and then placing both in water gradually heated until the substance melts, the temperature being then noted. Terreil proposes to modify this method by melting the substance separately and then by means of a glass rod a single drop is deposited on the thermometer bulb, which is then placed above a gas flame at such a distance that the heating is very slow. The temperature is read at the instant the substance melts, and the whole is allowed to cool and the solidifying point noted; this operation being repeated several times. In this method the phenomena of surfusion disappear, the fusing and solidifying points coinciding sensibly. For fusing points above 100° the thermometer should have a larger bulb, so that it changes temperature slowly.—*Bull. Soc. Ch.*, II, xxxi, 155, Feb. 1879. G. F. B.

2. *On Chromium, Manganese, Iron, Nickel and Cobalt Amalgams.*—Moissan has shown that when a concentrated solution of chromous chloride in water is agitated with a pasty sodium amalgam there is produced a chromium amalgam. After removal of the excess of sodium by boiling in water for an hour, the amalgam is obtained as a liquid, less fluid than mercury, covering itself on standing in the air with a black layer of oxide, decompos-

ing slowly in dry air, more rapidly in presence of water. Heated to above the boiling point of mercury in a current of hydrogen, it leaves a residue of metallic chromium, as a black amorphous mass, which heated on platinum foil becomes incandescent and leaves a residue of green chromic oxide. The chromium made by this process is not acted on by boiling concentrated sulphuric acid, but dissolves in dilute sulphuric acid and in strong nitric containing nitrous acid. Hydrochloric acid when hot attacks it slowly, evolving hydrogen. The amalgams of manganese, of cobalt, and of nickel which were obtained in this way have a pasty consistence and contain more of the metal than the chromium amalgam. Manganese amalgam was also obtained by electrolysis by decomposing a solution of manganous chloride, using a negative electrode of mercury. When distilled at 440° pulverulent manganese was obtained, which became incandescent when treated with a few drops of fuming nitric acid, and which decomposed water slowly at ordinary temperatures, rapidly at 100°. Since the production of this amalgam polarizes the electrodes, it is probable that the richness of the amalgam is definite for a given battery.—*Bull. Soc. Ch.*, II, xxxi, 149. G. F. B.

3. *On Chromates and Dichromates.*—SCHULERND at Kolbe's suggestion, has examined the conditions under which dichromates of the metals are formed. He examined the salts formed with barium, lead, mercury, silver, thallium and lithium, using precipitation for their preparation in all but the latter case. With barium, lead, and mercury, only the normal chromate $R'CrO_4$, could be obtained, either by precipitating with potassium dichromate or by evaporating with excess of chromic acid. With silver, thallium and lithium on the other hand, dichromates were readily obtained. Silver nitrate is precipitated by potassium dichromate, yielding a dark red crystalline powder of silver dichromate, $Ag_2Cr_2O_7$. Thallous carbonate gives thallous chromate when precipitated by potassium chromate and thallous dichromate when thrown down by the dichromate in acid solutions. The chromate and dichromate of lithium are well crystallized salts, the former having a pure yellow, the latter a dark orange, almost black color. Each has two molecules of crystal water, both are deliquescent, and lose their crystal water at 130°.—*J. pr. Ch.*, II, xix, 36, Jan. 1879. G. F. B.

4. *On the Purification of Mercury.*—BRÜHL has proposed to use chromic acid for the purpose of purifying mercury, and has freed twenty-five kilograms of mercury from Wood's fusible metal with which it was contaminated, in two hours by its means. Five grams of potassium dichromate are dissolved in a liter of water, a few cubic centimeters of sulphuric acid are added, and the mercury is shaken with its own volume of the solution. The metal divides into small globules, a little red chromate being formed. The agitation is continued until this red powder has disappeared and the solution has become green. By a strong current of water, a gray powder of metallic oxides is washed away, and the process is re-

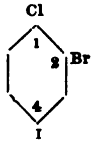
peated if necessary. The accumulated mercury of five years of the author's laboratory, some of which had been used to amalgamate zincs and was semi-solid, was completely purified in an afternoon in this way. The loss is small, two kilograms of mercury, after three treatments with 100 c.c. of the acid solution, washing, heating to 150° and weighing, lost only 10 grams.—*Ber. Berl. Chem. Ges.*, xii, 204, Feb. 1879. G. F. B.

5. *On Eikosylene, a hydrocarbon from the Paraffin of Brown coal.*—LIPPMANN and HAWLICZEK have examined the chlor-derivatives of paraffin from various sources, in order to determine the molecular weight of these bodies. In the first place, the paraffin of commerce was found uniformly to contain oxygen, from which it must be freed by repeated treatment with sodium in a sealed tube heated to 250°. Thus purified the brown-coal paraffin had, after recrystallization from alcohol, a melting point of 37° C. To produce the chloride it was at first treated with twice its weight of phosphoric chloride diluted with carbon tetrachloride, and heated in a sealed tube to 215°. But subsequently it was melted in a balloon at 170°, and the phosphoric chloride added as required through a wide tube, in the necessary quantity. The residue of the operation was liquid. After washing with water, it was separated from the unacted-on paraffin by cooling to —15° C. and fractionated in vacuo. An oily liquid was obtained in this way which boiled at 225° to 230° and afforded on analysis the formula $C_{20}H_{39}Cl$, having evidently been produced from the body $C_{20}H_{40}Cl_2$ by loss of HCl. Distillation at the ordinary pressure decomposed it further, $C_{20}H_{39}Cl = C_{20}H_{38} + HCl$. The hydrocarbon thus obtained boiled at 314°—315°, and the authors propose for it the name eikosylene. Its specific gravity is 0·8181, but its vapor density could not be determined, since it totally decomposed at 440°. It acts like an olefine, combining actively with halogens, forming a chloride $C_{20}H_{38}Cl_2$ and a corresponding bromide. It belongs to the acetylene series, being homologous with cetylene $C_{16}H_{30}$ its highest member. The evidence that the hydrocarbon $C_{20}H_{42}$, mixed perhaps with others of higher boiling point, constitutes the paraffin of brown coal, seems well established.—*Ber. Berl. Chem. Ges.*, xii, 69, Jan. 1879. G. F. B.

6. *On the Transformation of Starch into Dextrose in the Cold.*—It is known that starch is slowly transformed into dextrose when boiled for a long time with water. RIBAN has made some observations which seem to show that the same result may take place in the cold, though much more gradually. A solution made by boiling one part of finely divided starch in 100 of water saturated with salt, and filtering, is imputrescible and may be preserved for a long time. After a year the author's solution appeared less sensitive to iodine, and after three or four years, it was not colored by this reagent. It was neutral, limpid, contained no trace of any organized ferment, reduced energetically the copper test and was browned by alkalies. Determined by the copper test, every 100 c.c. contained 0·111 gram dextrose; but using ferricyanide of potas-

sium which is not affected by dextrin, 100 c.c. contained 0·102 gram. Hence a mixture of nine-tenths dextrose and one-tenth dextrin was formed from the starch. The solution, in a tube 200 mm. long rotated to the right; $a_D = +0·15°$. The author calls attention to the importance of this transformation of starch in the cold, without a ferment, in the physiology of vegetable growth.—*Bull. Soc. Ch.*, II, xxxi, 10, Jan. 1879. G. F. B.

7. *On the Structure-formulas of Aromatic Compounds.*—The present method of representing aromatic isomers is either graphic, by the use of the letters *p*, *m*, or *o*, standing for para, meta or ortho, or by using figures to represent the positions. Thus the structure of the compound C_6H_3ClBrI may be represented by

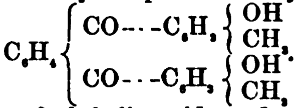


or by $C_6H_3\overset{1}{Cl}\overset{2}{Br}\overset{4}{I}$. Wroblevsky proposes a simpler mode of expressing the position of the replacing atoms, writing the formula differently according as the two replacing atoms are symmetrically or unsymmetrically arranged or occupy neighboring positions. Thus, for example, the chlorine derivatives of benzene may be written in this way so as to express all the facts in a much less space:

Empirical.	Symmetrical.	Unsymmetrical.	Neighboring.
$C_6H_4Cl_2$	$C_6H_2ClH_2Cl$	C_6H_3ClHCl	$C_6H_3Cl_2H$
$C_6H_3Cl_3$	$C_6HClHClHCl$	$C_6H_2ClHCl_2$	$C_6H_2Cl_3H$
$C_6H_2Cl_4$	$C_6HCl_2HCl_2$	$C_6HClHCl_3$	C_6HCl_4H

So if the positions 1, 2, 3, 4 in the benzene ring be filled by chlorine, bromine, iodine and hydrogen, the formulas will be $C_6H_2ClBrHI$, $C_6H_2BrClHI$, $C_6H_2IClHBr$, $C_6H_2BrIHCl$, $C_6H_2ClBrIH$, $C_6H_2BrClIH$, etc. In the first of these formulas the Cl is symmetrical with the I, is in the neighboring position with the Br, while the Br and I are unsymmetrically situated. So the naphthalene derivative which has I in the position 4 and Cl in 6, may be written $C_6HClH_2(C_4IH_2)$ or $C_6H_2ClH(C_4H_2I)$.—*Ber. Berl. Chem. Ges.*, xii, 161, Feb., 1879. G. F. B.

8. *On the Phthalein of Orthocresol.*—Fraude has extended the production of Baeyer's phthaleins by producing the phthalein of orthocresol



$$C_6H_4\left\{\begin{array}{l} CO\text{---}C_6H_3\left\{\begin{array}{l}OH\\CH_3\end{array}\right. \\ CO\text{---}C_6H_3\left\{\begin{array}{l}OH\\CH_3\end{array}\right. \end{array}\right.$$

For this purpose two parts cresol, three of phthalic oxide and two parts of stannic chloride were heated together to 120° for 8 to 10 hours. The cresol unacted on was removed by a current of superheated steam, the mass was dissolved in solution of soda, and precipitated by hydrochloric acid, this process being repeated once or twice. Solution in alcohol, decolorization with bone black, and dilution with water, gave the phthalein in flesh-red crusts. The diacetyl, dibenzoyl, dinitro, and dibrom derivatives are described, as also mono-orthobromcresol-phthalein and its barium compound. By heating cresol and phthalic oxide with sulphuric acid, methyloxyanthraquinone is produced; and this heated to 200° C. with excess of potash yields methylalizarin. The phthalins, phthalidins and phthalideins corresponding to the phthaleins of orthocresol are described in the same memoir.—*Ber. Berl. Chem. Ges.*, xii, 237, Feb. 1879. G. F. B.

9. *Baryta and Strontia.*—The fact that the compounds of baryta and strontia occur in nature in very different associations has long been recognized by mineralogists, and in the December No. of the Ann. de Chim. et de Phys., M. Dieulafait has published an interesting paper which offers a plausible explanation of this difference of occurrence. In the first place the author established the fact that both baryta and strontia are present in sensible quantities in the feldspars and micas of the older crystalline rocks. He examined feldspars from fifty-four different localities, and also micas in numerous associations, besides eighty specimens of granites in mass, sixty of gneiss and many of syenite, and in all of these he discovered not only lime but also strontia and baryta. From various circumstances, but especially from the association of barite with metallic sulphides in mineral veins it is inferred that the alkaline earths are dissolved from the rocks as sulphides, and the author promises us in a future paper a discussion of the nature of the sulphuretted solvent. It is next argued, from the known reaction of the carbonic dioxide and oxygen of the atmosphere on a solution of strontic and baric sulphides, that such a solution while flowing off in contact with the air would deposit, in the first place, the carbonates of these bases nearest to the source, and, subsequently at a greater distance the sulphates, thus determining a separation between the two groups of minerals. Again the sulphate of strontia, being more soluble than the sulphate of baryta—and, according to the author, existing relatively in much larger quantities in the crystalline rocks—would be to a much greater extent washed down by the running streams; collecting in salt basins, and in the layers of gypsum, which are deposited in these basins; while on the other hand the more insoluble sulphate of baryta would be left behind. Lastly the strontium reduced from the condition of sulphate to sulphide by the organic matter in the gypsum beds—and thus becoming very soluble—again undergoes the same reactions in contact with the air to which we have just referred, giving rise first to an insoluble carbonate and a solution of a polysulphide and then to a sulphate and free sulphur. Thus are explained the facts that celestine is found almost always in beds of gypsum and associated with crystals of sulphur. It is argued in conclusion that if the circumstances of the occurrence of celestine and barite at the present day differ so widely that this arises solely from the fact that the strontium compounds found in salt-beds are in the second stage of their development, while the corresponding

compounds of baryta left in the veins of crystalline rocks are in the first stage; and that in spite of all present differences of occurrence and association, the baryta and strontia minerals may be traced to the same origin in the old crystalline rocks of the earth's crust. J. P. C.

11. *The illumination of gases by Electric discharges.*—Professor E. **Wiedemann** continues his work upon the nature of spectra, and shows that a gas having a temperature far below 100° C. can be illuminated by electrical discharges. By means of a small calorimeter, in connection with a peculiarly arranged exhaustion tube, Professor Wiedemann was enabled to arrive at the amount of heat communicated to the gas under examination at different pressures. The temperature of the gas in the beginning was in the neighborhood of 20° C. and reached a maximum of from 80°–90° by means of the discharges from a Ruhmkorf coil, even at this temperature the gas was brilliantly illuminated; and the temperatures of 62°–70° was not found to be the lowest at which the gas was illuminated.

The illumination of the gas at such low temperatures is produced, Professor Wiedemann thinks, by an exaltation of the living force of the oscillatory movements of the ether envelopes. The electrical discharge calls forth this action independently of the increase of molecular movement which results from the increase of temperature.—*Annalen der Physik und Chemie*, No. 2, 1879, p. 298. J. T.

12. *A new current interrupter.*—Dr. F. **Niemoller** describes an extremely simple and efficacious form of interrupter. To the middle of a wire stretched horizontally is attached a platinum point which touches the surface of mercury in a little containing vessel. The current is led over this wire, and a magnet over the half of the wire through which the current is conducted serves to maintain the vibrations of the wire. The number of vibrations can be readily modified by changing the length of the wire, and as high a number as 1000 breaks in a second can be obtained. By passing an intermittent current over the wire it can be set in vibration without the intervention of mechanical means. This happens when the fundamental note of the string is in unison with the pitch of the interrupter.—*Annalen der Physik und Chemie*, No. 2, 1879, p. 302. J. T.

13. *The dimensions of Molecules.*—R. **Rühlmann**, by means of the formula

$$\lambda = \frac{1}{\sqrt{2}} \; \frac{\delta^3}{\pi\rho^2},$$

in which λ represents the mean path of the molecules, δ the mean distance between the molecules and ρ the radius of their sphere of action, calculates the sum of the molecular sections. Since $N\delta^3 = 1$, if N represents the number of molecules in the unit of volume, we have

$$\frac{N\rho^2\pi}{4} = \frac{1}{4\sqrt{2}\lambda}$$

According to Avogadro's law equal volumes of different gases under the same pressure and temperature contain the same number of molecules, the ratio of the sum of the sections is the ratio of the section of the molecules themselves. Bearing this in mind, one is justified, since the mean accuracy of the numbers found can be depended upon within eight per cent, in regarding, in the following tables, the numbers found for the two-atom molecules, with the exception of chlorine, hydrogen and hydrochlorine, as equal among themselves, and the section of the hydrogen molecules as one-half and that of chlorine as twice as great. The three-atom molecules of CO_2, of N_2O, of H_2O and of H_2S have the same molecular sections and stand in relation to the large number of two-atom gases as 3 : 2 or as the number of atoms. To this law SO_2 is an exception, since its molecular section is the same as that of chlorine. H_3N and HCl take a decided position. Possibly CH_4 can be included with them, since the mean of these three numbers is related to the molecular section of the two-atom molecule nearly as 4:3. One is also tempted to regard the molecular sections of C_2H_4, of SO_2, of chlorine, and CH_3Cl as equal and as double that of the two-atom molecule.

The following table includes the sum of the molecular sections of each gas in a cubic centimeter, expressed in square centimeters.

	H_2	9100	approximately	9000	$= 1 \times 9000$
Two-atom	O_2	16900	"	18000	$= 2 \times 9000$
	N_2	18000	"	18000	
	CO	18200	"	18000	
	NO	18700	"	18000	
Three-atom	CO_2	26700	"	27000	$= 3 \times 9000$
	N_2O	26800	"	27000	
	H_2O	26400	"	27000	
	H_2S	28600	"	27000	
	CH_4	21600	"	24000	$= \frac{8}{3} \times 9000$
	H_3N	23400	"	24000	
	HCl	24200	"	24000	
	C_2H_4	31600	"	36000	$= 4 \times 9000$
	SO_2	36700	"	36000	
	Cl_2	36700	"	36000	
	CH_3Cl	39300	"	36000	

Professor Rühlmann also gives the following values of ρ.

For nitrogen molecule $= 34 \cdot 10^{-9}$ cm.
For carbonic dioxide molecule $= 16 \cdot 10^{-9}$ cm.
For hydrogen molecule $= 41 \cdot 10^{-9}$ cm.

At 0° and 760 mm. pressure a cubic centimeter holds nearly 100 trillions of gas molecules. Under these conditions the molecules themselves fill nearly the three-thousandth part of the space occupied by the gas. The absolute weight of a hydrogen molecule is represented by $15 \cdot 10^{-23} g$ and the specific weight as 360.—*Beiblätter Annalen der Physik und Chemie*, 1879, No. 2, p. 57.

J. T.

14. *American Chemical Journal;* edited, with the aid of Chemists at home and abroad, by IRA REMSEN, Professor of Chemistry in the Johns Hopkins University. Vol. i, No. 1, 76 pp. 8vo. Baltimore, April, 1879.—The establishment of this American Chemical Journal is an event of great importance to the science of the country. The Journal could not be in better hands; for the editor, Professor Remsen, is both a man of thorough learning in his department, and an able and hard-working investigator. The number just issued compares well in its memoirs with the best of other lands. The subjects of some of these are: the Complex inorganic acids, by Wolcott Gibbs; Nitrogen iodide, by J. W. Mallet; on Lockyer's hypothesis that the so-called Elements are compound bodies, by C. S. Hastings; a New Volumetric method of determining Fluorine, by S. L. Penfield; on the Oxidation of substitution-products of aromatic Hydrocarbons, by Ira Remsen and M. W. Iles. The Journal is to be issued every other month; the subscription price is three dollars a year.

II. GEOLOGY AND NATURAL HISTORY.

1. *Fossil Forests of the Volcanic Tertiary Formations of the Yellowstone National Park;* by W. H. HOLMES. (Bull. U. S. Geol. and Geogr. Survey, Vol. v, No. 1.)—The volcanic Tertiary deposits (tufas, etc.) of the Yellowstone region have a thickness of more than 5,000 feet. They contain silicified trunks of trees in many places. Mr. Holmes describes particularly a section on the north face of Amethyst Mountain, in which upright trunks occur at many levels, along with others prostrate, from near the foot to the highest stratum. On the steeper part "rows of upright trunks stand out like the columns of a ruined temple," and on the slopes lower down, the petrified trunks fairly cover the surface. Some of the prostrate trunks are fifty to sixty feet long and many are five to six feet in diameter. The upright trunks are occasionally thirty feet high; and one twelve feet high was ten in diameter, and its bark was four inches in thickness. There are also leaves and stems, and Lesquereux has identified among them *Aralia Whitneyi*, *Magnolia lanceolata*, *Laurus Canariensis*, and new species of *Tilia*, *Fraxinus*, *Diospyros*, *Cornus*, *Pteris* and *Alnus*.

2. *Fruit-bearing branch of Cordaites from Cannelton, Pennsylvania.*—In the Proceedings of the American Philosophical Society for April, Professor Lesquereux has described a specimen of Cordaites bearing fruit, collected by Mr. I. F. Mansfield at Cannelton. It is a bent or pendent branch twelve centimeters long and nearly one and a half broad, having the fruit arranged spirally in a loose strobile-like way. The winged nut or fruit is oval, 3 centimeters long, 2·3 broad, and broadly obtuse and entire at top. It indicates, according to Mr. Lesquereux, that the Cordaites are allied to the Cycads, or rather are an antecedent type intermediate between Cycads and Conifers.

3. *Annual Report of the Wisconsin Geological Survey, for the year* 1878; by T. C. CHAMBERLIN, Chief Geologist. 52 pp. 8vo. Madison, Wis., 1879.—This Report contains observations on the recent glacial drift of the Alps, and on the bearing of the facts on Wisconsin surface geology, by Professor Chamberlin.

4. *The Woodland Caribou or Reindeer* (*Rangifer Caribou*) *from the Lœss of Iowa.*—Dr. LEIDY announces the discovery by Professor Witter, in the lœss of Muscatine, Iowa, of fragments of the upper and lower jaws and some other bones of this species. From the same locality Professor Witter collected the shells *Helix striatella*, *H. fulva*, *H. pulchella*, *H. lineata*, *Pupa muscorum*, *P. Blandi*, *P. simplex*, *Succinea obliqua*, *S. avara*, *Limnea pumilis?* and *Helicina occulta.*—*Proc. Acad. Nat. Sci. Philad.*, 1879, p. 32.

5. *Amber and Asphaltum from Vincenttown, New Jersey.*—Mr. E. GOLDSMITH reports these minerals from the Ash Marl of the Cretaceous, a layer above the Green-sand. The mass of asphaltum weighed 100 pounds. The amber is stated to be related to the variety of succinite called Krantzite by C. Bergemann. Unlike ordinary amber its specific gravity is less than 1, and it fuses to a mobile liquid. This amber is of occasional occurrence in the New Jersey Cretaceous; "sometimes hundreds of tons may be looked over without finding a single piece; and at other times enough has been found to fill a barrel within a day."—*Ibid.*

6. *Guides for Science-Teaching.* —This is the title of a few primers, published by the Boston Natural History Society, and meant to supplement and enforce lectures given by members of that Society to Teachers of the Public Schools of Boston. These teachers are all required to give to their pupils a certain number of *object lectures.* But who shall teach the teachers, and wherewithal shall they be taught? Well, a few public-spirited ladies supplied the material means for a free course of instruction to five or six hundred teachers, and two or three individuals contributed their knowledge and experience, and carried into execution an admirable plan. The substance of the lessons of this course, given by Mr. Hyatt and Professor Goodale, is exhibited and preserved in these primers. The plan was to speak of nothing which was not shown, and not only shown but placed in the hands of the auditors. And this not by specimens passed round, and so reaching most of the pupils after the discourse had passed on to something else; but each hearer was supplied with a whole suite of the objects lectured on, to examine at the moment and to take home for further examination and review.

The first lesson, by Mr. Hyatt, is *About Pebbles.* A tray placed before each pupil holds a small quantity of fresh-broken rock, a weathered piece with worn angles, a complete and rounded pebble, a spoonful of gravel and another of sand. With these, and with reference to what every one remembers to have seen on shores and beaches, in quarries and stone-yards, and along brooks and roadsides, the lesson proceeds, and the elemental facts are taught rather by questions asked and by observations incited than by didactic lecturing.

The second primer contains the substance and displays the method of Professor Goodale's course of lessons "*Concerning a Few Common Plants.*" For the first lesson, on a seedling, each of the five hundred auditors, supposed normally to represent a child-pupil, had before him a bean freshly soaked, another the sprouting of which in germination had barely commenced, a third with germination more advanced, a fourth which had developed not only a root below, but the first two leaves above the cotyledons. The discourse opens by the asking of some simple questions, every one of which must be answered by an examination of these objects. The second lesson compares two seedlings, viz. the pea with the bean; the third compares still other and different seedlings; and by this time the pupils have made out the leading facts and ideas of vegetable morphology as it were for themselves. This knowledge is extended in a similar way, and by the comparison of various leafy shoots, to the consideration of "how the parts of plants help one another." Later these parts, roots, stems, and leaves are taken up separately; then the way in which plants feed and grow is taught; then wood is illustrated by small truncheons, blocks variously cut, and veneers, of which each pupil has a set; and the structure and morphology of the blossom is brought out by similar methods. Teachers so taught should be able to give "object lessons" to their young pupils with some success. Those who have not the advantage of such training should send for these primers (costing ten and twenty cents apiece) study them thoroughly, and follow the directions they give.

The third primer, about Commercial and other Sponges, is very good, but different. It begins aright with a bath sponge, and some common reef-sponges to be had cheaply of the wholesale druggists. But it departs from the normal plan by entering into microscopic details, illustrated by figures, and into an account of sponge-gathering by divers in the Mediterranean and the Gulf of Mexico. A. G.

7. *Function of the Sterile Filament of Pentstemon.*—Dr. Léo ERRERA, in Belgium, has been investigating two allied Mexican species, viz. *Pentstemon gentianoides* and *P. Hartwegi*, with their varieties, now common in cultivation. Noting the fact that the sterile filament, which belongs to the upper side of the flower, is from near its base, declined upon the lower side of the corolla-tube or throat, he comes to the conclusion that its principal function is to obstruct the access of unwelcome insects to the nectar at the base of the flower. The size of the corolla and disposition of the genitalia is such that only large insects, such as humble bees, which fill the whole cavity, can effect fecundation. The somewhat smaller ones, which would rifle the flower of its sweets without rendering any service, are excluded from the nectar by this bar across the base of the tube. Professor Kerner,

who of late has especially studied the arrangements in flowers for the exclusion of unbidden guests, as he terms them, appears to have anticipated this conclusion in respect to *Pentstemon.* While making observations upon the five forms of these two species which were in cultivation at Brussels, Dr. Errera was surprised to find that only one of them was freely visited by hymenopterous insects: this was a form of *P. Hartwegi*, with mauve-colored corolla. The others, though occasionally tried, were, on the whole, neglected; and he found that this remarkable preference depended not at all upon the abundance or quality of the nectar, nor upon the perfume, nor upon the color of the corolla, except by a coincidence as to the latter; but in the fact, that in all but the mauve-colored form, the curvature of the sterile filament, which obstructed further entrance, was so high in the tube that the tongue of these insects could not reach the nectar at the bottom of the tube. A difference of a millimeter or two in the curvature of the sterile filament or the length of the tube below, determined whether or not the flowers should be fertilized in Belgium.

Errera's paper is published in the 17th volume of the *Bulletin de la Société Royale de Botanique de Belgique*, February, 1879, is preceded by a very detailed dissertation on the structure and fecundation of flowers in general, by himself and M. Gustave Gevaert, occupying 140 pages, 8vo. The motto of the paper is taken from Darwin—"Whoever is led to believe that species are mutable, will do good service by conscientiously expressing his conviction." The authors have expressed theirs, and the grounds of it, with great fullness. A. G.

8. *Revue Mycologique*, is the title of a new periodical, devoted to the study of *Fungi*, under the editorship of M. Roumeguère of Toulouse, published at that city and at Paris (Baillière); the first number, of 44 pages, 8vo, issued in January last. Price 12 francs a year. The leading article is upon the Lichen question, in the light of the recent investigations of Dr. Minks, confirmed by Dr. Mueller of Geneva. Half of this first fasciculus is devoted to notices of recent publications and to mycological news. The editor takes notice of Professor Hitchcock's recent proposition to the microscopists in the convention at Indianapolis, to adopt the $\frac{1}{100}$ of a millimeter as the micrometric unit, and regrets it, on account of the adoption, several years ago, in Europe (upon the proposition of Suringar of Leyden) of the $\frac{1}{1000}$ of a millimeter (denoted by the Greek μ) as the micrometric unit. A. G.

9. *Meehan's Native Flowers and Ferns of the United States*, illustrated by chromolithographs of Prang & Co.—The whole of vol. ii, issued since our last notice, is now before us. The new volume, parts 13 to 24, compares very favorably with the first. The drawings are better; the color-printing at least as good; and the excursions in the letter-press comparatively seldom tempt the reviewer to critical remarks. Such plates as those of *Phaseolus diversifolius*, *Andromeda Mariana*, *Cerastium arvense*, *Helianthus Maximiliana*, and *Echinocatus polycephalus*, even satisfy the

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fastidious. Perhaps we should have added *Gaillardia amblyodon* to the list, if we had not placed by the side of it Sprague's figure in the Chloris Bor.-Am., which belongs to some of this artist's early work. We could wish that Meadow Beauty (*Rhexia Virginica*) had a better opportunity to display her charms. We learn that the work will be directly continued in a second series, in which we hope that the success of the enterprise will stimulate still further improvement in the drawings. A. G.

10. *Observations on Several Forms of Saprolegnieæ;* by Frank B. Hine, B.S.—This is a thesis, submitted for the degree of B.S., at Cornell University, and the pamphlet is an article extracted from the American Quarterly Microscopic Journal, vol. i. It is illustrated by four excellent plates, drawn by the author from nature. The figures and the letter press (20 pages) give a very favorable impression of the author's ability, judgment, and taste. The two latter qualities are shown in his forbearance to give new specific names to forms of which the sexual reproduction is not made out, notwithstanding their apparent difference from described species; and he refrains from proposing a new genus in another case upon a new point of structure which he observed, but which may not require or justify this distinction. An indisposition to introduce new names which may be needless, and therefore encumbering, is a hopeful sign. A. G.

11. *A Popular California Flora, or Manual of Botany for Beginners;* by Volney Rattan, Teacher of Natural Sciences in the Girls' High School, San Francisco. (S. Francisco: Bancroft & Co. 1879).—The schools of California have long been needing an aid like this by which they may study the flowers which abound around them, and which in spring make gay the whole face of the country. This book, of 103 pages, in the form of "How Plants Grow," is the first and a laudable attempt to supply a pressing want. It is a first part only, including the Polypetalæ and Gamopetalæ, and a second part will complete the work. It is very well compiled from the Botany of California and the Synoptical Flora of North America; and it is restricted to the plants of the San Francisco region, extending north to Mendocino County, south to Monterey, and west to the foot-hills of the Sierra Nevada. The *Umbelliferæ* and *Compositæ* are omitted because "too difficult for beginners." In a second edition these might be added, and rendered about as easy as the rest, with a skillful popular presentation, for which we could give the worthy author some hints. A. G.

12. *Halosphæra, eine neue Gattung grüner Algen aus dem Mittelmeer;* by Dr. Fr. Schmitz.—The present paper, taken from the first volume of Mittheil. aus der Zoologischen Station at Naples, gives an account of a minute floating Alga, which is common in the Bay of Naples from January to April, and is vulgarly known as "punti verdi." Pelagic Algæ are little known, and the present species offers several points of interest. It occurs in the form of isolated spherical cells which float on the open sea, without any independent power of locomotion. The cell-contents divide into very numerous daughter-cells which produce zoöspores

by secondary division. The latter are of an unusual form, being conical, with the two long cilia attached to the base instead of to the apex of the cone. The development of the zoöspores is unknown.

In this connection we may mention a second paper by the same author on *The Green Algæ of the Bay of Athens.* He considers the little known *Acrocladus mediterraneus* of Nægeli to be merely a peculiar condition of the common *Cladophora pellucida* of Kützing, and not the young of *Acetabularia*, as was supposed by Zanardini. He describes two new species of *Siphonocladus*, a genus midway between *Valonia* and *Cladophora*, resembling the latter in ramification but differing from it in the transverse cell-walls not being complete, but only partial as in *Valonia.* At the end of the paper are some remarks on the relations of different genera of green Algæ, which constitute the *Siphonocladiaceæ.*

G. W. F.

13. Dr. W. G. Farlow, for the past five years Assistant Professor of Botany at the Bussey Institution, Harvard University, has been appointed Professor of Cryptogamic Botany in the University proper. This is the first professorship in this important and difficult department established in this country. The laboratory for instruction and research in the lower Cryptogamia is now established at Cambridge.

III. Miscellaneous Scientific Intelligence.

1. *Intra-Mercurial Planet.*—Careful search was made at the Royal Observatory, Greenwich, and other places for the transit of the supposed intra-Mercurial planet over the Sun, which, according to an orbit calculated by Dr. Oppolzer, of Vienna, might take place in the morning of the 19th of March last. Nothing, however, was seen of it—a result which cannot surprise those accustomed to astronomical observations, and able to appreciate the great uncertainty of the data on which the calculations were founded, several of the observations (among which we, for our part at least, must include the famous one by the Orgères physician, M. Lescarbault, in 1859) being probably of some spot on the Sun or else altogether apocryphal. With regard to the objects seen during the total solar eclipse last July, Dr. Oppolzer's orbit did not take in either of them.—*Athenæum*, April 12.

2. *Geological Society of London.*—At the recent annual meeting of the Geological Society, the Wollaston gold medal was awarded to Professor Bernard Studer, "the father of Swiss geology;" the Murchison medal to Professor M'Coy, of Melbourne; the Lyell medal to Professor E. Hébert, of Paris; the Bigsby medal to Professor E. D. Cope, of Philadelphia; the balance of the Wollaston Donation Fund to Mr. Samuel Allport; the proceeds of the Murchison Geological Fund to Mr. J. W. Kirkby; a moiety of the balance of the proceeds of the Lyell Fund to Professor Alleyne Nicholson, and the other moiety to Dr. Henry Woodward, F.R.S. —*Nature*, March 13.

3. *Geological Survey of the Territories of the United States.*—The plan proposed by the Committee of the National Academy of Sciences for the scientific surveys of the United States Territories (this Journal, January, 1879, p. 78), was accepted by Congress, just at the close of the last Session, (March 9th), so far as it relates to the Geological Survey. The position of Director of the Survey has been given to Mr. Clarence King, who has recently brought the Survey of the 40th Parallel to a successful completion. Congress has also appropriated a sum of twenty thousand dollars for the final completion of each of the three Surveys, which have been carried on up to this time under Lieut. Wheeler, Dr. F. V. Hayden, and Major Powell.

4. *Gold Medal of the Astronomical Society.*—The Council of the Royal Astronomical Society of England has awarded the gold medal of the society for this year to Professor Asaph Hall of Washington. In the address of the President, Lord Lindsay, on presenting the medal, a detailed statement is made of Professor Hall's many and valuable contributions to astronomical science, with special reference to the most important of these: the discovery of the satellites of the planet Mars.

5. *Paris Academy of Sciences.*—The "Serres" Prize for 1878 has been awarded by the Academy of Sciences, for the best work in embryology, to ALEXANDER AGASSIZ, of Cambridge. This is the first time the prize has been given. The value of the prize is 7500 francs.

Prof. J. Lawrence Smith has recently been elected a Corresponding Member of the Academy, in the place of Sir Charles Lyell.

6. *Memoirs of the Museum of Comparative Zoology.* — The first part of No. 1, vol. vi, of the Memoirs of the Museum of Comparative Zoology at Cambridge, Mass., has just been published. It contains a portion (288 pp.) of a work on the Auriferous Gravels of the Sierra Nevada of California, by Professor J. D. Whitney. The remainder of the volume will be ready in a few months.

7. *Report of the Observations of the Total Solar Eclipse, July 29th*, 1878, *made at Fort Worth, Texas;* edited by LEONARD WALDO, Assistant of the Observatory of Harvard College. 60 pp. 4to, with 4 plates. Cambridge, 1879.—A notice of this report will be given in another number.

OBITUARY.

FRANK HOWE BRADLEY died, from the falling of a bank in a gold mine, near Nacoochee, Georgia, on the 27th of March. Mr. Bradley was born at New Haven, Connecticut, on the 20th of September, 1838. He was graduated at Yale in 1863, and afterward pursued special studies in natural science in connection with the Sheffield Scientific School. But still earlier, his tastes had led him to the study of geology, and in 1857, before he had passed his nineteenth birthday, he had by his discoveries at Keeseville added a new trilobite to the known fauna of the New York Potsdam sandstone, which till then had afforded no animal remains but Lingulæ and Scolithi; and had proved by imperfect specimens the existence also of Crinoids and Pleurotomariæ in the same beds. This discovery was announced that year at the meeting of the American Association at Montreal, and made the subject of an article in this Journal in 1860. After his graduation at Yale, much of his time was spent in the field making collections of fossils, and, for more than a year, at Panama and its vicinity where he obtained large collections of corals and other specimens in zoology, partly for the Yale Zoological Museum. During the year 1867 he was assistant geologist in the survey of Illinois, and, in 1869, in that of Indiana. The Indiana report for that year contains a valuable chapter by him, treating especially of the Vermilion County Carboniferous rocks. Two species of land snails from these rocks were described by him in this Journal, in 1872. During the summer of that year he was assistant geologist in the geological survey of the Territories under Dr. F. V. Hayden, and among his important results, as set forth in his excellent report, there is the identification by fossils of the Quebec group in Idaho, and also at the base of the Archæan Teton range. During the years 1869 to 1875, Mr. Bradley was Professor of Geology and Mineralogy in the University of Tennessee; and while there he made a detailed section of the unaltered Lower Silurian formations and the continuation of the beds in crystalline rocks on the east; and the results of his careful work are embodied in a communication to this Journal in 1876 "on the Silurian age of the Southern Appalachians." During the same year he prepared, and in 1876 published, a valuable, though small, geological map of the United States.

Professor Bradley left his position at Knoxville in 1875, with the hope of so adding to his resources, that he might be able to pursue his favorite science untrammeled by outside obligations; and it was in laboring toward this end, but before his expectations had been realized, that he met with his untimely death.

Professor Bradley was a man of profound zeal for science, of exactness in observation, of great energy, and of independent judgment and purpose. His tall, straight figure, neatly dressed, but after a fashion dictated by his work and not by prevalent modes, exhibited his independence of character no less than his strongly drawn physiognomy. His lines of action were laid down by his sense of what was right and just, and once fixed, even if bearing only on the position of a comma in a proof sheet, there was no swerving. He even contemned any accommodation to circumstances in order to avoid friction, and met with more of this than he need have encountered. But he was a man of real kindness of heart, of warm friendships, and of great uprightness.

Professor Bradley was married to Miss Sarah M. Bolles of New Haven, in 1867. He leaves a wife and one young daughter, an infant child having died on the day of his own death. J. D. D.

Dove, the eminent professor of Physical Geography at Berlin, died on the 6th of April, at the age of seventy-seven.

W. K. Clifford, of University College, London, an able mathematician, died at Madeira, early in March.

THE

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[THIRD SERIES.]

ART. LIII.—*The Forests of Central Nevada, with some remarks on those of the adjacent regions;* by CHARLES S. SARGENT.

To the traveler crossing the Great Basin by the line of the Pacific Railroad the country will appear almost as destitute of trees as the great plateau over which he has passed in approaching the Rocky Mountains from the east. This first impression will disappear, however, should he penetrate farther south, and ascend some of the low mountain ranges, which, with a general north-and-south trend, everywhere cut up this elevated interior region into long, narrow valleys. As compared with our Atlantic forests, or those still nobler ones which, farther to the west, owe their existence to the influence of the Pacific, the forests which clothe, with a scanty and stunted vegetation, the mountain slopes of Nevada are miserably poor in extent, productiveness, and especially in the number of species of which they are composed. Actually they are of immense value. For scanty as they are, they regulate and protect the rare and uncertain streams on which the agriculture of Nevada depends, and furnish a large population with fuel and lumber; a population, too, which, while consuming and wasting enormously its forests in vast mining operations, is practically cut off, by its isolation and the cost of transportation, from outside supply.

A hurried journey made in Septemper last, undertaken for the purpose of studying *in situ* the trees of the "Great Basin," and of introducing into cultivation some of the peculiar plants of that region, took me to the great mining center of Eureka, and then through Dry and Fish-spring valleys seventy-five miles further southwest into the Monitor Range, to the point where its highest peak, "Table Mountain," reaches an elevation of 11,200 feet, and offered an excellent opportunity to examine the timber supply of that central portion of Nevada.

The forests of this portion of the State are composed of but seven species. Of these, two, the Red Cedar (*Juniperus Virginiana* L.) and the Aspen (*Populus tremuloides* Michx.) extend across the Continent; two, *Pinus Balfouriana* Murr. and *Pinus flexilis* James, extend along the mountain ranges from the Rocky Mts. of Colorado to Mt. Shasta in California; two, *Pinus monophylla* Torr. and *Juniperus Californica* Carrière, var. *Utahensis* Engelm. are endemic to the "Great Basin;" while *Cercocarpus ledifolius* Nutt., although occurring as a shrub both in the Rocky Mts. and in California, only here becomes a valuable tree.

Neither the Red Cedar nor the Aspen needs be considered here. A single small plant of the former was noticed; and it is evidently so rare throughout this region that it adds but little to the value of its forests. The Aspen borders all the mountain streams above 8,000 feet elevation, but, rarely surpassing fifteen feet in height and a few inches in diameter, is practically without value for its products. Further east in the Wahsatch Mts. this species is sometimes seen with stems two feet through; and it is largely used by the Mormons, who consider it valuable for flooring, turnery, etc.

Juniperus Californica, var. *Utahensis*, is the most common, and the most widely distributed of the trees of this region. It is found at lower elevations than any other tree, and alone descends into the valleys, where, at an elevation of 5,000 feet, it is often abundant, but less so than on the mountain sides, over which it spreads up to 8,000 feet elevation. It is a low, bushy tree, branching from the ground, with a stout trunk which rarely exceeds two feet in diameter; short and very stout branchlets, and thick shreddy bark. The wood, which is moderately hard, pale colored, and slightly aromatic, furnishes the common and cheapest fuel both for domestic use and for generating steam on the railroads and at the mines. The typical *Juniperus Californica* belongs to the California Coast Range, and the variety extends over the whole of the southern portion of the "Great Basin." In fruit this species will be readily distinguished by its dry one-seeded berry, the great thickness of the stony coating of the seeds; and from all other Junipers (as pointed out by Dr. Engelmann) by its 4–6-cotyledonous embryo. Without fruit it may be easily confounded with *Juniperus occidentalis* Hook., which species, however, has not been detected in Central Nevada. Like all the trees of the "Great Basin" this Juniper is of exceedingly slow growth. A specimen before me four and one-half inches in diameter shows one hundred and five annual layers of growth, or an annual average increase of nearly $\frac{1}{50}$ of an inch.

Growing with this Juniper, above 6,000 feet elevation, and extending rather higher up the mountains, is *Pinus monophylla* Torr., the "Nut Pine" of Nevada and eastern California; but not to be confounded with an allied species, also bearing edible seeds, *Pinus edulis* Engelm., found from Colorado to New Mexico and Arizona. *Pinus monophylla* is a small tree, ten to twenty feet high, with reddish scaly bark, and is easily distinguished from other North American Pines by its *solitary*, glaucous, terete leaves (very rarely in pairs, and then semi-cylindrical). The wood is white, soft, light, and very resinous; it is more highly prized for making charcoal than that of any tree of this region. In slowness of growth *Pinus monophylla* does not essentially differ from the Juniper with which it is associated; a specimen that I have examined, from the locality which furnished the specimen of Juniper referred to above, is five and one-half inches in diameter and shows one hundred and thirteen annual layers of growth. The immense crops of large and delicately flavored seeds produced by this tree supply, as is well known, to the Indian tribes of the Great Basin their most important article of food. The value of this crop, and the excellent quality of the wood for charcoal, make this tree, in a mining region entirely destitute of coal, its most valuable vegetable production. The introduction of *Pinus monophylla* into the South of Europe as a subject for forest planting is worthy of consideration; it might flourish there on those dry and exposed hill sides which have been found so difficult to satisfactorily recover with any European tree. Its strictly pyramidal habit while young—a habit which it entirely loses with age—and the pleasing glaucous tints of its foliage commend this species to the lovers of ornamental conifers.

*Pinus Balfouriana** was only met with on Prospect Mountain, near Eureka, at an elevation of 7,500 feet, to the summit, 8,000 feet. Formerly the whole summit of this mountain was very generally covered with this species, but with few exceptions the trees have all been cut to supply the mines with timbering, for which purpose the strong and very close-grained, tough wood of this species is preferred to that of any other Nevada tree. The specimens seen were fifteen to thirty feet high, with trunks often two feet in diameter, pyramidal in outline, their lower branches still remaining; so that at a little distance they might readily be mistaken for spruces. The bark like the wood is reddish in color, very thick and deeply furrowed; that of the branches smooth and quite white. The short, falcate, appressed leaves persist for years, forming tufts of foliage a foot or more long at the ends of the naked branches; and this peculiarity has suggested to the lumbermen of the region the name of "Fox Tail Pine" for this species. *Pinus Balfouriana*, should it be found to retain in cultivation the peculiarities which characterize it on the mountains of Nevada, will be one of the most striking and interesting of the genus for ornamental planting.

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* With the insufficient material at my disposal I cannot satisfactorily separate *Pinus aristata* Engelmann, from Murray's *P. Balfouriana*, the older name and founded on California specimens. *Pinus aristata* is an alpine plant discovered by Parry many years later in the Rocky Mts. of Colorado.

Pinus flexilis, the Nevada representative of the Eastern White and the California Sugar Pine, is the largest and the most valuable timber tree of the central portion of the "Great Basin." I found large tracts of it on the Monitor Range, from 8,000 up to 10,000 feet elevation; and further to the northeast it gives their names to "White Pine" District, "White Pine" Range, etc. On the Monitor Range specimens fifty to sixty feet high, and from two-feet six to four feet in diameter were not infrequent, the trees gradually becoming smaller as the elevation increased, until at 10,000 feet they were little more than prostrate bushes a foot or two high. The fact that the finest specimens were found on the banks of the mountain streams, associated with *Populus tremuloides*, indicates that this species is more dependant on moisture than the other Nevada Conifers. It is the only tree of this region which is sawed into lumber. The wood is soft, white, and, although not free from knots, is of fair quality, and about intermediate between Eastern white pine and sugar pine.

Cercocarpus ledifolius, with *Populus tremuloides*, the only non-coniferous tree of this region, here attains its largest size and greatest age. It is common at 6,000 to 8,000 feet elevation, and next to the Juniper and the Nut Pine is the most common of Central Nevada trees. It is a small tree, ten to thirty feet high, with small evergreen leaves and brown scaly bark, in habit and general appearance not unlike a stunted apple tree. The wood of this tree, which is of a bright mahogany color and susceptible of a beautiful polish, is exceedingly hard, heavy and close-grained, but very brittle, and so liable to "heart shake" and difficult to work as to be useless in the arts. It is, however, sometimes employed for the bearings of machinery, where it is found to wear as well as metal; but it is as fuel that "Mountain Mahogany" (the name by which, owing to the color of its wood, *Cercocarpus* is universally known) has no North American equal. We are in the habit of considering that our Eastern Hickories produce the best fuel. The specific gravity of dry hickory is but ·838, while that of *Cercocarpus* is 1·117, so that, weight being the best test, as fuel it is worth 30 per cent. more than hickory. The amount of ash, too, left after burning *Cercocarpus* is only $\frac{52}{100}$ of 1 per cent of the dry wood consumed, while that of hickory is $\frac{81}{100}$ of 1 per cent, three-tenths per cent more. *Cercocarpus* is probably the only North American wood which is heavier than water; and among the tropical woods employed in the arts and described by Lastett, but six equal or surpass it, the most conspicuous being the West Indian Lignum Vitæ (*Guaicum*) with a specific gravity of 1·243. As was to be expected, the growth of *Cercocarpus* was found to be exceedingly slow. An examination of several specimens from one to two hundred years old shows an average annual increase of wood only one-sixtieth of an inch in thickness. The largest specimen of this tree was seen on Prospect Mountain near Eureka, in New York Cañon, at an elevation of 7,000 feet. It was a low, much branched tree, about twenty feet high with a trunk rising six feet to the first branches. At three feet from the ground it had a girth of seven feet and five inches. If we suppose that its average growth had been as rapid as that of the younger specimens examined, this tree would have been 890 years old. It was probably much older. The rate of growth of trees is, after a certain age, in inverse ratio to their age; and it is perhaps permissible to suppose that the seed which produced this little tree had already germinated when the oldest living *Sequoia* on the Continent was still a vigorous sapling with its bi-centennial anniversary still before it.

Two shrubby plants of this region may be mentioned, which, from their beauty, are especially worthy of introduction to cultivation,—*Cowania Mexicana* Don., a large Rosaceous shrub, nearly allied to *Cercocarpus*, with elegant pinnatifidly-lobed leaves and large and very abundant yellow flowers; and a large shrubby *Spiræa*, *S. Millefolium* Torr., with the foliage of *Chamæbatia*, but a larger and more striking plant, and perhaps the most elegant of the genus.

It will have been seen that the forests of Nevada, consisting of a few species adapted to struggle with adverse conditions of soil and climate, are of immense age, and that the dwarfed and scattered individuals which compose them reach maturity only after centuries of exceedingly slow growth. On this account, and because, if once destroyed, the want of moisture will forever prevent their restoration, either naturally or by the hand of man, public attention should be turned to the importance of preserving, before it is too late, some portions of these forests. Large areas of forest-covered mountain ranges are still held by the General Government; and in view of the vast importance of their remaining wooded to serve as reservoirs of moisture, on the existence of which the future of this region must depend, it would seem wise and not perhaps altogether impracticable, to check, or at least to regulate, the terrible destruction of forest, which follows, both on public and private domain, every new discovery of the precious metals.

A comparison of the arborescent vegetation of Nevada with that of the region lying directly east and west of the "Great Basin" may be interesting. Such a comparison will serve to more clearly demonstrate the remarkable poverty of the Nevada forests. It will afford, too, another illustration of the relation of moisture to forest distribution, especially with reference to the multiplication of species, which will be found to increase or diminish as the rain-fall is more or less abundant and more or less equally distributed.

In the territory between the 41st and 37th parallels of latitude, and extending from the eastern base of the Rocky Mts. to the foot of the western slope of the Sierra Nevada are three distinct belts of arborescent vegetation.* Beginning at the east there is: 1. The Rocky Mountain Region including, besides the main range, the Uinta and the Wahsatch, and embracing Colorado and the eastern half of Utah; 2. The Nevada Region, extending from the western base of the Wahsatch, to the eastern base of the Sierra Nevada, and embracing the western half of Utah and the whole of Nevada with the exception of the extreme northern and southern portions of the State; 3. The Sierra Nevada Region.

In the Rocky Mountain Region, to which in spite of its mid-continental position considerable moisture is attracted by the high peaks which everywhere dominate it, there are twenty-five trees and forty-eight shrubs, in all seventy-three species. In the Nevada Region, where, owing to its isolated position between high mountain ranges, the rain-fall is small and very unequally distributed, the number of species is reduced nearly one-half,—to thirty-eight; ten trees and twenty-eight shrubs. In the Sierra Nevada Region, to which the Pacific contributes a large although unequally distributed, snow and rain fall, the number of species is increased to eighty-nine; of these thirty-five are trees,† or three and a half times more than occur in the adjoining Nevada Region, and a third more than are found in the Rocky Mountain Region; and fifty-four are shrubs, or double the number of the Nevada Region.

The following table shows the arborescent‡ and frutescent species, so far as they are now known, which occur in these three Regions.

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* For the purpose of the present comparison not only trees but all frutescent plants which may be expected to exceed four feet in height, and therefore as undergrowth to form an important element in the forest, will be included.

† *Pinus monophylla* Torr., although it has found a foothold on the eastern flank of the Sierra Nevadas, is not included among the trees of this region. This species, as well as *Artemesia tridentata*, are so peculiar to the Nevada Region that they cannot be properly considered a part of the Flora of the Sierra Nevada.

‡ Species which become large enough to be of economic value as timber trees, are designated by a *.

The Rocky Mt. Region.	The Nevada Region.	The Sierra Nevada Region.
Berberis Fendleri.	*Berberis Fremontii.*	
		Calycanthus occidentalis.
		Fremontia Californica.
Ptelea angustifolia.		
Rhamnus Californica.		*Rhamnus Californica.*
		Rhamnus alnifolia.
		Rhamnus crocea.
		Ceanothus cordulatus.
		Ceanothus integerrimus.
		Æsculus Californica.
*Acer grandidentatum.**		*Acer macrophyllum* *
Acer glabrum.	*Acer glabrum.*	*Acer glabrum.*
Negundo aceroides.		
Rhus glabra.		
		Rhus diversiloba.
Rhus aromatica, var. *trilobata.*	*Rhus aromatica*, var. *trilobata.*	*Rhus aromatica*, var. *trilobata.*
Robinia Neo-Mexicana.		
		Cercis occidentalis.
Prunus Pennsylvanica.		*Prunus subcordata.*
Prunus Virginiana.	*Prunus Andersonii.*	*Prunus emarginata.*
Prunus demissa.	*Prunus demissa.*	*Prunus demissa.*
Spiræa discolor, var. *dumosa.*	*Spiræa discolor*, var. *dumosa.*	*Spiræa discolor*, var. *dumosa.*
	Spiræa Millefolium.	
Neillia opulifolia.		*Neillia opulifolia.*
Rubus deliciosus.		*Rubus Nutkanus.*
Purshia tridentata.	*Purshia tridentata.*	
Coleogyne ramosissima.		
Cercocarpus parvifolius.		*Cercocarpus parvifolius.**
*Cercocarpus ledifolius.**	*Cercocarpus ledifolius.**	*Cercocarpus ledifolius.*
Cercocarpus intricatus.		
Cowania Mexicana.	*Cowania Mexicana.*	
		Adenostoma fasciculatum.
Rosa blanda.	*Rosa Californica*, var. *ultramontana.*	*Rosa Californica.*
Rosa blanda, var.	*Rosa blanda*, var.	
		Heteromeles arbutifolia.
Pyrus sambucifolia.		*Pyrus sambucifolia.*
Cratægus rivularis?		*Cratægus rivularis.*
Cratægus coccinea.		
Amelanchier alnifolia.	*Amelanchier alnifolia.*	*Amelanchier alnifolia.*
Peraphyllum ramosissimum.		
Philadelphus microphyllus.		*Philadelphus Lewisii.*
Fendlera rupicola.		
		Carpenteria Californica.
Ribes cereum.	*Ribes cereum.*	*Ribes cereum.*
Ribes aureum.	*Ribes aureum.*	*Ribes aureum.*
Ribes leptanthum.		*Ribes leptanthum.*
Ribes bracteosum.		*Ribes Menziesii.*
Ribes divaricatum, var. *irriguum.*		*Ribes oxyacanthoides.*
		Ribes sanguineum, var. *variegatum.*
Cornus pubescens.	*Cornus pubescens.*	*Cornus pubescens.*
		Cornus sessilis.
		Cornus Nuttallii.
		Garrya Fremontii.
Sambucus glauca.	*Sambucus glauca.*	*Sambucus glauca.*
Sambucus racemosa.		*Sambucus racemosa.*
Lonicera involucrata.	*Lonicera involucrata.*	*Lonicera involucrata.*
		Cephalanthus occidentalis.
Artemisia tridentata.	*Artemisia tridentata.*	
		Leucothœ Davisiæ.
		Arctostaphylos pungens, var. *platyphylla.*
		Rhododendron occidentale.
		Styrax Californica.
	Fraxinus anomala.	*Fraxinus dipetala.*
		*Fraxinus Oregona.**
Forestiera Neo-Mexicana.		

The Rocky Mt. Region.	The Nevada Region.	The Sierra Nevada Region.
		Eriodictyon glutinosum.
		Umbellaria (*Oreodaphne*) *Californica.**
Shepherdia Canadensis.	*Shepherdia Canadensis.*	
Shepherdia argentea.	*Shepherdia argentea.*	
	Shepherdia rotundifolia.	
Elæagnus argentea.		
Sarcobatus vermiculatus.	*Sarcobatus vermiculatus.*	
Atriplex confertifolia.	*Atriplex confertifolia.*	
	Spirostachys occidentalis.	
Celtis occidentalis.		
Celtis occidentalis, var. *pumila.*		
*Quercus undulata.**		*Quercus lobata.**
		Quercus lobata, var. *fruticosa.*
		*Quercus Douglasii.**
		*Quercus chrysolepis.**
		Quercus chrysolepis, var. *vaccinifolium.*
		*Quercus Sonomensis.**
		*Quercus Wislizeni.**
		*Quercus densiflora.**
		*Castanopsis chrysophylla.**
Betula occidentalis.		
Betula glandulosa.		
Corylus rostrata.		*Corylus rostrata*, var. *Californica.*
		Myrica Hartwegi.
Alnus incana.		*Alnus incana.*
Alnus viridis.		*Alnus rhombifolia.*
Salix longifolia.	*Salix longifolia.*	*Salix*, species.
Salix cordata.	*Salix cordata.*	*Salix*, species.
*Populus tremuloides.**	*Populus tremuloides.**	*Populus tremuloides.**
*Populus angustifolia.**	*Populus angustifolia.**	*Populus Fremontii.**
Populus balsamifera, var. *candicans.**	*Populus trichocarpa.**	*Populus trichocarpa.**
Epheda trifurca.	*Ephedra trifurca.*	
*Pinus contorta.**		*Pinus contorta.**
Pinus contorta, var. *latifolia.**		
*Pinus ponderosa.**		*Pinus ponderosa.**
		Pinus ponderosa, var. *Jeffreyi.**
*Pinus edulis.**	*Pinus monophylla.**	
*Pinus flexilis.**	*Pinus flexilis.**	*Pinus flexilis.**
*Pinus Balfouriana.**	*Pinus Balfouriana.**	*Pinus Balfouriana.**
		*Pinus Sabiniana.**
		*Pinus tuberculata.**
		*Pinus monticola.**
		*Pinus Lambertiana.**
*Picea Engelmanni.**	*Picea Engelmanni.**	
Picea pungens (*Abies Menziesii* of the Colorado Flora).*		
*Abies subalpina.**		
*Abies concolor.**		*Abies concolor.**
		*Abies magnifica.**
		*Abies nobilis.**
		Tsuga Hookeri (*Abies Williamsoni.*)*
*Pseudotsuga Douglasii.**		*Pseudotsuga Douglasii.**
		*Sequoia gigantea.**
		*Libocedrus decurrens.**
		*Taxus brevifolia.**
		*Torreya Californica.**
Juniperus occidentalis,var.*	*Juniperus Californica*, var. *Utahensis.**	*Juniperus occidentalis.**
*Juniperus Virginiana.**	*Juniperus Virginiana.**	
73 species. 47 genera. 19 timber trees. 6 small trees. 48 shrubs.	38 species. 26 genera. 10 timber trees. 28 shrubs.	89 species. 51 genera. 31 timber trees. 4 small trees. 54 shrubs.

The following species, fourteen in number, are common to the three Regions:

Acer glabrum.
Rhus aromatica, var.
Prunus demissa.
Spiræa discolor, var.
Cercocarpus ledifolius.
Amelanchier alnifolia.
Ribes cereum.
Ribes aureum.
Cornus pubescens.
Sambucus glauca.
Lonicera involucrata.
Populus tremuloides.
Pinus flexilis.
Pinus Balfouriana.

The following species, twelve in number, are, in addition to those named above, common to the Rocky Mt. and Sierra Nevada Regions:

Rhamnus Californica.
Neillia opulifolia.
Cercocarpus parvifolius.
Pyrus sambucifolia.
Ribes leptanthum.
Sambucus racemosa.
Alnus incana.
Pinus contorta.
Pinus ponderosa.
Abies concolor.
Pseudotsuga Douglasii.
Juniperus occidentalis.

All the species of the Nevada Region extend into the Rocky Mt. Region with the exception of the following ten species:

Berberis Fremontii.
Prunus Andersonii.
Spiræa Millefolium.
Rosa Californica, var.
Fraxinus anomala.
Shepherdia rotundifolia.
Spirostachys occidentalis.
Populus trichocarpa.
Pinus monophylla.
Juniperus Californica, var.

Populus trichocarpa is the only species (with possibly the two willows) of the Nevada Region, which, in addition to the fourteen species common to the three Regions, extends into the Sierra Nevada. So that fifteen species of the Nevada Region reach the Sierra Nevada Region, while twenty-eight species extend into the Rocky Mountain Region, leaving but ten species peculiar to the Nevada Region. Of these *Fraxinus anomala* and *Shepherdia rotundifolia* are endemic; the other eight species extending south into Arizona.

The following genera common to the Sierra Nevada and Atlantic Forests, have no representatives in the mid-continental Flora:

Calycanthus.
Æsculus.
Cercis.
Cephalanthus.
Leucothoë.
Rhododendron.
Styrax.
Myrica.
Tsuga.
Torreya.

The following genera of the Sierra Nevada Region have no Eastern representatives:

Fremontia.
Adenostoma.
Heteromeles.
Carpenteria.
Garrya.
Eriodictyon.
Umbellaria.
Castanopsis.
Sequoia.
Libocedrus.

The absence of arborescent and frutescent *Leguminosæ* from the three Regions, where herbaceous genera of this order are so largely represented, is remarkable, especially as they abound farther south in New Mexico and Arizona. In the Rocky Mt. Region there is a single representative of this order, a *Robinia* nearly allied to those of the Eastern States; in the Nevada Region there is not a single frutescent *Leguminosa*, and in the Sierra Nevada but one species, a large shrubby *Cercis*. On the contrary the number of genera of frutescent *Rosaceæ*, many of them endemic and monotypic, is very large in proportion to other *Angiospermæ*. In the Rocky Mt. Region there are thirteen genera with nineteen species; in the Nevada Region seven genera with ten species; in the Sierra Nevada Region eleven genera with thirteen species; in all, fourteen genera with twenty-eight species. In all the United States east of the Mississippi River there are but ten woody Rosaceous genera, all represented in our three Regions with the exception of the Southern *Chrysobalanus* and *Neviusia*.

The comparison of these three Regions with reference to the distribution of the oaks will show how dependent these are on moisture. Oaks abound in both the Atlantic and Pacific forests, while in the Rocky Mt. Region there is but a single, exceedingly polymorphous species, which does not reach the Nevada Region, where no oak is known; nor has this genus, so far as I know, any foot-hold on the dry eastern slope of the Sierra Nevada. A few insignificant species extend, however, along the mountains of Arizona and New Mexico, where the precipitation of moisture is more regularly distributed than farther north, and serve to connect the oaks of the Pacific with those of the Atlantic forests.

The absence of *Pinus ponderosa* from the Nevada Region is remarkable. This species abounds in all the Rocky Mt. Region, and extends through New Mexico and Arizona to the Sierra Nevada, where, on the dry eastern slope, it constitutes in some of its forms fully three-quarters of the forests. It might therefore be naturally looked for on some of the higher mountains of Central Nevada, where, however, it has not yet been seen.

Pseudotsuga Douglasii, which also abounds in the Rocky Mt. Region, and on the higher mountains of New Mexico and Arizona, does not enter the Nevada Region. This is less remarkable, perhaps, than the absence of *Pinus ponderosa*, as this tree does not appear, in any numbers at least, on the eastern slope of the Sierras, and only reaches its noblest development in the humid climate of the northwest coast.

Juniperus Virginiana, the most widely distributed of North American trees, ranges from the Saint Lawrence River to Florida, and from the Atlantic to the Northern Pacific. It does not, however, enter the Sierra Nevada Region, and is extremely rare in Nevada.

ART. LIV. — *On Ethylidenamine Silver Sulphate;* by W. G. MIXTER. Contributions from the Sheffield Laboratory of Yale College, No. LVI.

ALDEHYDE AMMONIA precipitates metallic silver from many of its salts almost as readily as from the nitrate. A mixture of solutions of silver sulphate and aldehyde ammonia produces a mirror when warmed, and at common temperatures evaporates to dryness, with but slight decomposition. The fact that a sulphate solution decomposed less readily than the nitrate led to the hope that an investigation of the sulphate compound would throw more light on the constitution of silver amines. The first experiments were made with ammoniacal aqueous solutions of silver sulphate and aldehyde ammonia. Analyses proved the crystalline product to be a mixture. Alcoholic ammonia was next used as a solvent, and the analysis of the first crop of crystals showed nearly pure $Ag_2SO_4(NH_3)_4$, 0·6 per cent of carbon was found and a solution of the crystals reacted for aldehyde. Aqueous solutions of silver sulphate and a large excess of aldehyde ammonia, over four molecules of the latter to one of the former, yielded either mixtures or ammonio silver sulphate. When, however, aldehyde ammonia is dissolved in a small quantity of water, and silver sulphate, in the proportion of one molecule of the latter to four molecules of the former, is slowly added with constant agitation; and after some hours the small black residue filtered off and the solution left to spontaneous evaporation, few or no crystals of the ammonio sulphate form, but colorless transparent crystals separate, which react strongly for aldehyde. At summer temperatures tabular crystals, and at from 10° to 15° C. elongated crystals, predominate.

The following analyses were made of carefully selected and well-defined tabular crystals, which were from 2 to 5^{mm} in diameter, and which were freed as much as possible from the mother liquor by blotting paper, then washed with alcohol and finally with ether. They were considered dry when they did not lose weight on the balance in five or ten minutes.

	Calculated for $Ag_2SO_4(C_2H_4NH)_4$	I.		II.		III.		Calculated for $Ag_2SO_4(C_2H_4NH)_3$ NH_3
S	6·61	6·68						
Ag	44·64	44·55	2	48·60	2	46·03	2	47·10
C	19·83	18·13	7·4	15·90	5·9	16·27	6·2	15·72
H	4·13	4·62		4·14		4·31		3·95
N	11·57	11·28						12·20
* *	* * *	* * *	* *	* * *	* *	* * *	* *	* * *
$3H_2O$	10·04	10·24		10·50		10·39		10·15

	Calculated for $Ag_2SO_4(C_2H_4NH)_3NH_3\,3H_2O$	IV.		V.			
Ag	42·20	42·08	2	41·08	2	41·07	2
C	14·06	13·92	5·9	14·73	6·4	14·77	6·4
H	4·69	4·91		4·88			
N	10·90	10·64					
* *	* * *	* * *	* *	* * *	* *	* * *	* *
$3H_2O$	10·15			10·20			

The following results were obtained from crystals of an entirely different habit from those used in the preceding analyses, many of the crystals were one or two centimeters long, 4 or 5^{mm} wide, and 1 to 3^{mm} in thickness. They were freed from the mother liquor in the manner already described.

	Calculated for $Ag_2SO_4(C_2H_4NH)_4 6H_2O$	VI.		Calculated for $Ag_2SO_4(C_2H_4NH)_4$	VII.			
S	5·40	5·26	1					
Ag	36·48	36·12	2	44·64	44·70	2	43·89	2
C	16·21	15·66	7·8	19·83	18·72	7·6	18·79	7·6
H	5·41	5·6		4·13	4·43		4·52	
* *	* * *	* * *	* *	* * *	* * *	* *		
N	9·46	9·06	3·9					
$6H_2O$	18·24	17·29			17·67			

The atomic relations between the silver and carbon found are expressed by the figures following the percentages. The combustion for I was with lead chromate, and this carbon result may be too low, as subsequent duplicate combustions on another lot of crystals gave variations of 1 per cent of carbon. All the other combustions were made with oxygen, copper oxide, lead chromate and metallic copper. The silver in I and VI was weighed as chloride, and the other silver estimations were from weighing the residue left in the tray after the combustions, a method necessitated by the small quantity of material available. The duplicate VII shows the possibility of a mechanical loss. An error of 1 per cent in the silver found makes but a small difference in the atomic ratio between the silver and carbon, since the atomic weight of the former is high. The sulphur was precipitated as barium sulphate, and the nitrogen as ammonium platinic chloride, after separating the silver with hydrochloric acid. The water was determined by drying over oil of vitriol or caustic potash. A drop of sulphuric acid on a watch glass in the potash desiccator showed that there was a slight loss of ammonia on drying. The weights of substance for VI from one crop of crystals were made rapidly. 0·7395 gram was at once placed in the combustion tube whose anterior half was red hot; 0·438 gram was next put into water for the nitrogen estimation, and finally 0·533 gram of crystals, which had become opaque white on edge, were dried to a constant weight for the water determination, and then used to find the sulphur content. The 17·67 per cent of water in VII was from drying 2·37 grams of crystals which had also become opaque while on edges.

Analysis VI corresponds with the theory, and the anhydrous material used in VII was from the same kind of crystals. The deficiency in the amount of carbon found may be ascribed either to impurities or a slight decomposition. I after losing water of crystallization, has essentially the same composition as VII. Both I and VI are hydrates of a compound analogous to ammonio silver sulphate, thus,

$$\begin{array}{l} Ag_2SO_4(NH_3)_4 \\ Ag_2SO_4(CH_3CH{=}NH)_4,\ 3H_2O \\ Ag_2SO_4(CH_3CH{=}NH)_4,\ 6H_2O \end{array}$$

The name ethylidenamine silver sulphate is proposed for the present.

Analysis IV was made with hydrous crystals, and II with anhydrous substance from the same crop of crystals which were apparently of the same form as the crystals which gave results I. II and IV, give the formula,

$$Ag_2SO_4(CH_3CH{=}NH)_3NH_3,\ 3H_2O.$$

Leaving out the $3H_2O$ we see that the substance has the same composition as a mixture of 3 molecules of $Ag_2SO_4(C_2H_4NH)_4$ and one molecule $Ag_2SO_4(NH_3)_4$. But if we suppose it a mixture of $Ag_2SO_4(C_2H_4NH)_4$, $3H_2O$ and $Ag_2SO_4(NH_3)_4$ we find that the water is 8·1 per cent and does not accord with the water found, and the conclusion is that the substance analyzed was not a mixture, but a compound containing three ethyliden groups, and answering to the formula already given. III and V of two different crops of crystals appear to be mixtures of $Ag_2SO_4(C_2H_4NH)_4$, $3H_2O$ and $Ag_2SO_4(C_2H_4NH)_3NH_3$, $3H_2O$. Ethylidenamine silver sulphate is soluble in water and yields aldehyde when treated with acids. The hexhydrated salt loses water more readily in dry air than the trihydrated.

ART. LV.—*Notes on the Satellites of Saturn;* by MARIA MITCHELL.

THE object glass of the telescope used in the observations which follow is of twelve and one-third inches diameter. Its definition is good.

The telescope is used in such observations as its very imperfect mechanism will allow; these are observations of the conjunctions of the satellites with the edge of Saturn's ring, of size and color, and of differences of right ascension.

The last are made by connecting with the chronograph, and recording the time of passage of the satellites over a fixed wire.

In the course of these observations such different relative magnitudes have been given to the small satellites, on different evenings, as to lead to the suspicion that some of them are variable.

The sparkle of Tethys and the grayish blue color of Rhea make it seem unlikely that small stars can have been taken for these two satellites; in the case of Enceladus and Dione mistakes are more easily made; but the rapid motion of Enceladus soon establishes its identity. The most noticeable changes are in Rhea.

In 1877, Rhea is recorded as small on Nov. 30th; as dull on Dec. 3d; as blurry and large, Dec. 14th; and as ruddy, Dec. 18th. In 1878 Rhea is recorded as faint Oct. 3d and Oct. 16th; as bright on Oct. 25th, and on Dec. 3d it is called nearly as bright as Titan.

1877, Oct. 5.—Rhea was in conjunction with the preceding edge of the ring at $8^h\ 58^m\ 29^s$ P. M. Two small satellites following the planet were in conjunction at the same time; the smaller one moved rapidly toward the ball.

1877, Oct. 6.—Two small satellites were nearly in conjunction with the edge of the preceding ring at $9^h\ 28^m$ P. M. The smaller of these was probably Dione; the larger may have been a star.

1877, Oct. 9.—$10^h\ 8^m$ P. M. Tethys is moving away from the ball and has passed conjunction with the ring. Another satellite, probably Enceladus, is coming in, and is nearly up to conjunction with the following edge of the ring.

1877, Oct. 13.—At 10 P. M., two small satellites were seen to be nearly together following Saturn, the space between them being $1''\cdot5$. At $10^h\ 53^m\ 31^s$, the two satellites could not be separated with a power of 400. The two were of the same size. At $11^h\ 20^m\ 31^s$, the satellites could be seen separated. These may be Tethys near greatest elongation, and Enceladus approaching the planet.

1877, Oct. 14.—Rhea was in conjunction with the preceding edge of the ring and above the ring at $9^h\ 9^m\ 30^s$.

1877, Oct. 23.—Rhea was again in conjunction with the preceding edge of the ring and above it, at $10^h\ 29^m\ 22^s$.

1877, Nov. 6.—Tethys was in conjunction with the preceding edge of the ring at $9^h\ 31^m\ 30^s$.

1877, Nov. 7.—Tethys was in conjunction with the following edge of the ring and above the ring at $9^h\ 22^m\ 50^s$.

1877, Nov. 13.—Dione was in conjunction with the following edge of the ring at $8^h\ 44^m\ 6^s$.

1877, Nov. 14.—Titan was in conjunction with the preceding edge of the ring at $8^h\ 7^m\ 6^s$.

1877, Nov. 16.—Enceladus was in conjunction with the following edge of ring and beneath it at $9^h\ 51^m\ 6^s$.

1877, Nov. 17.—The seeing was excellent. Two satellites, probably Tethys and Enceladus, were seen as one at $6^h\ 29^m\ 24^s$. In twenty minutes they had separated 3″. Rhea was in conjunction with the following edge of ring at $6^h\ 45^m\ 21^s$ and 3″ below the ring. Dione was nearly at conjunction with the preceding edge of ring at 7 P. M.

1877, Nov. 30.—Titan was in conjunction with the preceding edge of the ring at $7^h\ 17^m\ 1^s$. A small satellite (Tethys?) a little past conjunction and above the ring at $8^h\ 10^m$.

1877, Dec. 12.—Tethys was in conjunction with the preceding edge of the ring and below it at $6^h\ 48^m\ 49^s$.

1877, Dec. 14.—A small satellite preceded the ring by one and three-fifths the measurement of the preceding ansa. Was this Mimas? The time was $7^h\ 34^m$.

1877, Dec. 16.—Titan was in conjunction with the preceding edge of the ring at $6^h\ 19^m\ 36^s$.

1878, Jan. 12.—$5^h\ 50^m$ to 6 P. M. The ring of Saturn appeared as a line. Titan preceded the planet and three small satellites followed, two of them estimated to be a second of arc only asunder. The distance from the following edge of the ring to the two satellites so closely together was nearly twice that from the ball to the edge of the ring.

1878, Jan. 16.—Observations began at $4^h\ 50^m$ P. M. The ring was seen as a line at $5^h\ 12^m$, its following portion being seen first. A bright spot was seen on this portion of the ring.

1878, Jan. 18.—The night was very fine, and at 6 P. M. the ring could be seen as a ring. The preceding portion of the ring was sharper than that following. On the following portion a bright spot was seen.

1878, Jan. 29.—At $5^h\ 25^m$ P. M. the ring could be seen as a bright line across the planet. Titan preceded the planet and four satellites followed. At $6^h\ 40^m$ a very faint satellite was seen (Tethys?) nearly up to conjunction with the ring and moving toward the ball.

1878, Feb. 7.—$6^h\ 30^m$ P. M. Points of light could be seen preceding Saturn, but the continuity of the ring could not be kept. A small point of light, possibly a satellite preceded the ring. Rhea and Titan followed the planet.

1878, Oct. 3.—$8^h\ 40^m$ P. M. Two satellites, supposed to be Rhea and Dione, are nearly in conjunction and preceding the planet. Two others follow, Tethys moving out and Enceladus (?) nearly at conjunction with the ring. Of the four satellites, Tethys is the brightest.

1878, Oct. 16.—Titan was in conjunction with the edge of the following ring at $7^h\ 38^m$; above the ring.

1878, Oct. 24.—Titan was seen emerging from the ball of Saturn at $9^h\ 16^m\ 30^s$. 7^h P. M.—A very faint satellite was seen by glimpses, following, nearly in conjunction with the ring.

1878, Oct. 25, 7 P. M.—Titan and another satellite supposed to be Rhea were nearly in conjunction separated by 7″. A very small satellite precedes the tip of the ring.

1878, Oct. 28.—Tethys was in conjunction with the edge of the following ring and below at $7^h\ 37^m$ P. M.

1878, Oct. 29.—Tethys was nearly at conjunction with the preceding ring and above at 7 P. M.

1878, Nov. 9.—At $8^h\ 18^m\ 3^s$ Titan was seen to emerge from the planet. It was wholly detached from the planet in twenty minutes. At $9^h\ 25^m$ P. M., a small satellite was seen, nearly at conjunction with the following ring.

1878, Nov. 13.—Six small bodies preceded Saturn. Of these, Titan, Rhea, Tethys and Dione could be identified. At $7^h\ 48^m$ P. M. the satellite supposed to be Rhea is distant from the preceding ring 6″, Tethys is distant 1″.

1878, Nov. 14.—$7^h\ 30^m$ P. M. A very small satellite follows Saturn, distant about 3″.

1878, Nov. 26.—Titan and a satellite supposed to be Rhea were asunder 6″ 3′ at $7^h\ 22^m$. If this satellite was Rhea, it was unusually bright. Tethys and a very faint satellite precede Saturn, the latter is probably Enceladus.

1878, Nov. 29.—At $6^h\ 15^m$ P. M. a small satellite preceded Saturn and three others followed. Of those following, that which was nearest to Saturn could not be found at 9 P. M., and the second in distance from Saturn had moved in; the latter was probably Tethys.

1878, Dec. 3.—Dione was in conjunction with the following edge and above the ring at $7^h\ 46^m\ 34^s$ P. M. A small satellite was seen by glimpses, following at a distance of 6″ from the ring.

1878, Dec. 6.—At $6^h\ 25^m$ a small satellite followed Saturn distant 7″ from the edge of the ring. This satellite could not be found at $7^h\ 55^m$ although the seeing was much better. At $7^h\ 55^m$ a small satellite having the peculiar sparkle of Tethys, was seen a little beyond the following edge of the ring, and moving away from the ball.

1878, Dec. 13.—Titan and three small satellites precede the planet, probably Rhea, Tethys and Dione. Of the three, Tethys is the brightest at $6^h\ 57^m$. It moves away from the ball. At $8^h\ 57^m$ two of these satellites could not be separated with a power of 230. I suppose them to be Tethys and Rhea.

1878, Dec. 16.—$9^h\ 5^m$ P. M. Tethys was nearly up to conjunction with the ring; moving toward the ball. Rhea was large and dull in color.

Observatory of Vassar College.
Longitude from Greenwich, $4^h\ 55^m\ 33{\cdot}9^s$.

Art. LVI.—*On the Force of Effective Molecular Action*; by Professor W. A. Norton.

[Continued from page 358.]

For the critical curve the molecular repulsion has very nearly the constant value, $0{\cdot}0052\frac{m}{r^2}$, from $x=3r$ to $x=7{\cdot}5r$; and according to Dr. Andrews, the pressure of condensation at the critical point for carbonic acid gas was seventy-five atmospheres. These data give for the molecular repulsion answering to one atmosphere, $\dfrac{0{\cdot}0052\frac{m}{r^2}}{75}=0{\cdot}0000693\frac{m}{r^2}$. This should then be the value of the minimum repulsive ordinate, that obtains when $x=3r$, in the curve for water at the point of ebullition (212° F.). This result gives for this curve $k=4{\cdot}931$. In this curve the same molecular repulsion occurs again at $x=115r$. Now taking 1581 for the ratio of expansion by volume of water converted into steam at 212° F., and for the distance between the effective molecules of the steam, $115r$, and putting $y=$ distance of the inner surface of the effective envelope from the center of the molecule, I have

$$\frac{115r+2r+2y}{3r+2r+2y}=\sqrt[3]{1581};$$

which gives $y=2{\cdot}76r$. This calculation proceeds on the supposition that the effective molecules have the same size in the vaporous as in the liquid state, but theoretically they should be larger; and we shall see in the sequel that the probable value of the diameter of the molecules of steam is $42{\cdot}25r$. If we adopt this estimate, the ratio of expansion by volume, 1581 to 1, gives for the diameter of the liquid molecule at 212° F., $10{\cdot}5r$.

Let us now see how far the well known laws of gases may be deduced from our molecular formula.

(1). *Avogadro's Law*, relative to the simple gases; that all simple gases contain in the same volume, at the same pressure and temperature, the same number of ultimate molecules. This law follows from the fact that for the large distances between contiguous molecules, that obtain in gases, the effective repulsion is very nearly the same at the same distance for all the values of k that can answer to the different gases; together with the large size of the effective gaseous molecules. The entire possible range of value for k, for gases and vapors, is from 0 to $4{\cdot}934$; since it is only between these limits that the effective molecular force is repulsive at all distances. We have already seen that when $k=4·931$, and $x=115r$, the effective repulsion is $0·0000693p$; and that this answers to one atmosphere of external pressure. When $k=0$ and $x=115r$, the effective repulsion is $0·00007561p$; and the distance x at which the repulsion becomes $0·0000693p$ is $120r$. But the distances between the centers of the molecules must be much greater than these values of x. It will soon appear that the law of Mariotte requires that the radius of the effective gaseous molecule, under a pressure of one atmosphere, be not less than $31r$. This gives for the distance between the centers of the molecules, under this pressure, $177r$ when $k=4·931$; and $182r$ when $k=0$. Now $\left(\frac{182}{177}\right)^3=1·086$. This is the highest ratio of volumes of two simple gases, under atmospheric pressure, that would be theoretically possible; unless the effective size of the molecules be supposed to diminish as k increases. But this is only an ideal extreme result. It will appear in the sequel that the values of k for the simple gases, oxygen, hydrogen and nitrogen, for which Avogadro's law, for a constant pressure and temperature, has been experimentally established, are included within narrow limits (probably 2 and 3). It thus becomes apparent that the extreme ratio of the number of molecules in the same volume cannot exceed 1·013, and may be much less.

(2.) *Avogadro's Law*, relative to compound gases; that the same volumes of these gases contain the same number of molecules, and the same number as equal volumes of the simple gases. The ordinary physical conception is that compound molecules are formed by the union of simple molecules, or of a certain number of their constituent atoms, and that these occupy the same volume that the simple molecules did. In some instances of chemical combination it necessitates the supposition that the formation of each new compound molecule is a result of the breaking up of several molecules of the combining substances. It also involves the improbable hypothesis that the space physically occupied by a molecule is wholly independent of the number of its constituent atoms. Upon the conception of variable ultimate molecules adopted in this and my previous paper, Avogadro's law simply implies that in the act of combination the effective molecules suffer a certain diminution of size, by the collapse of their envelopes. The same number of atoms may thus physically occupy the same volume as if they were closely to unite and form a compound molecule, upon the ordinary hypothesis. Thus in the formation of aqueous vapor by the combination of two volumes of hydrogen with one volume of oxygen, forming two volumes of the compound, a condensation of the individual molecules would take place, and as the result two ultimate molecules of hydrogen and one of oxygen would occupy the same volume that three molecules of either gas did before the combination. It is to be observed, in confirmation of this view of the process of combination, that the reduction in the size of the effective molecules, would be attended with an increase in the ratio k, and a consequent increase in the value of the attractive term in equation (1), for the same value of x (or graphically, a rise of the curve of effective molecular action; see fig. 3).

The compound should therefore be a more condensable gas, or vapor. We have already obtained for aqueous vapor, at 212° F., $k=4{\cdot}931$; and it will appear hereafter that for oxygen, hydrogen, or nitrogen, the value of k must fall below 4, and is probably near 2. To obtain the theoretical size of the effective molecules of aqueous vapor, we have the equation $\frac{118r+62r}{115r+y'}=\sqrt[3]{\frac{3}{2}}$. This gives $y'=42{\cdot}25r$, and radius of molecule$=21{\cdot}12r$. The distance between the centers of contiguous molecules will be $157{\cdot}25r$. In this equation $118r$ is the distance between contiguous molecules of oxygen or hydrogen before condensation, and answers to $k=2$, nearly; and $62r$ is the diameter of one of the molecules (see page 436): $115r$ is the distance between the same molecules after the condensation into aqueous vapor; when k has been increased to $4{\cdot}931$.

In all combinations of simple gases the degree of condensation that occurs is expressed by the ratio of the number of atoms in the "compound molecule," as shown by the ordinary molecular formula, to 2, the assumed number of the constituent atoms of "the molecule" of a simple gas. In this statement it is supposed that the constituent gases before combination are in the perfect gaseous condition, like oxygen, or hydrogen, and that the compound gas has the temperature at which it is in a similar condition; so far as these two suppositions are implied in Avogadro's law.

Mariotte's, or Boyle's Law, of the uniform compressibility, by volume, of gases under increasing pressure. Upon the present theory this law should obtain if the effective molecular repulsion be inversely proportional to the volume occupied by the same number of molecules, or to the cube of the distance between the centers of contiguous molecules. For each molecule would then be the center of a system of recurring impulses propagated in waves by the interstitial luminiferous ether, proportional in intensity to the number (n) of molecules in a unit of volume, and every line radiating from any point of the enclosure into the body of gas would sensibly intersect a molecule at a greater or less distance. To obtain the entire impulsive action (P) on the point considered, we have then only to conceive a hemisphere traced around this point, and that all the points of its surface are centers of radiating impulses proportional in intensity to n, and propagated according to the law of inverse squares. P should then be proportional to the intensity of the radiation at the points of the hemisphere, and therefore to n.

Now the expression for the effective molecular repulsion (equ. 1) consists of two terms of which the first, or attractive term, becomes relatively very small at the molecular distances that obtain, at moderate pressures, in gases (p. 346). The repulsive term, $\frac{m}{x^2}$, gives, then, very nearly the effective force, at such pressures; and more nearly in proportion as the ratio $\frac{n}{m}$ is smaller. Mariotte's law should then be satisfied, for considerable variations of pressure if the term $\frac{m}{x^2}$ should vary inversely as the cube of the distance (x') between the centers of contiguous molecules; that is, if $\frac{1}{x^2} \div \frac{1}{x'^3}$. If we denote by h the radius of the effective molecule, $x' = x + 2h$. As we are not in a position to determine à priori the law of variation of the size of the molecule under varying pressures, the only alternative is to adopt the hypothesis that $\frac{1}{x^2} \div \frac{1}{x'^3}$, deduce a series of values of the diameter $2h$, of the effective molecule that shall be in conformity with this hypothesis, and then test the results and hypothesis by deducing the theoretical deviations from the law of Mariotte in special cases, and comparing them with the deviations experimentally determined. Now I find that the hypothesis that $\frac{1}{x^2} \div \frac{1}{x'^3}$ is satisfied by the following values of $2h$, viz: 62·10, 62·00, 61·26, 60·32, 58·96, 57·12, 54·70, 51·58, 47·54, 42·24, 35·14, 30·53, 24·74, 16·89, 12·57,—answering respectively to the following values of u (equ. 2): 120, 115, 100, 90, 80, 70, 60, 50, 40, 30, 20, 15, 10, 5, and 3. Theoretically one gas differs from another in the value of k, and the larger this ratio the greater should be the deviations from the law of Mariotte, which strictly is fulfilled only when $k=0$, and so the attractive term in our formula equal to zero. These deviations should also increase as the pressure increases, since the attractive term will become relatively greater. The more permanent simple gases (oxygen, hydrogen, etc.), for which the law of Mariotte holds good over the greatest range of pressure, should then have the smallest values of the ratio k; and compound gases the larger values (see p. 435). We may now assume, as a basis for an approximate calculation, that the molecules of all the gases have equal diameters under equal pressures, and we may then compute for any supposed value of k the volume that should obtain under any supposed pressure, and compare it with the value that would result if the law of Mariotte were strictly fulfilled. Dr. Andrews, in his Bakerian Lecture on the continuity of the gaseous and liquid states of matter, states that under a pressure of forty-nine atmospheres, at the temperature 13°·09 C.; the volume of carbonic acid gas was "about $\frac{3}{5}$ of the volume that Mariotte's law would give." The critical temperature of the gas he found to be 30°·92 C., and we have seen (p. 357) that for the critical curve $k=4{\cdot}7$. This gives for the temperature 13°·09 C. $k=4{\cdot}75$ (very nearly). Now calculating the volume for this value of k, and under a pressure of 49 atmospheres, I obtain 0·648 of the volume (V) Mariotte's law would give. Experiment gave 0·60V. By what has already been stated (p. 434), the actual diameter of a molecule of carbon-dioxide, under the pressure of one atmosphere, should be less than $62r$, the diameter assumed for molecules of oxygen and hydrogen. Taking it $52r$, I have deduced from the hypothesis that $\frac{1}{x^2} \div \frac{1}{x'^3}$ another series of values of the diameter $2h$; and making a new calculation, I find the theoretical volume $=0{\cdot}613$V. The ratio of condensation from the perfect gas in the production of carbon dioxide (see p. 435) would lead us to conclude that the diameter of the molecule, at the temperature 13°·09 C. would be less than 50 (possibly as low as 40). Taking it at 40 I obtain by estimation the theoretical volume $=0{\cdot}58$V. I have made other similar test calculations, with the aid of Dr. Andrews' experimental determinations with similar results.

Gay Lussac's Law of the uniform variation of the volume of a gas under constant pressure, as well as of the elastic force under a constant volume, resulting from a change of temperature. This may be deduced from the principle which gives Mariotte's law, that the molecular repulsion varies inversely as the volume, and the principle that it is directly proportional to the coefficient of repulsion (m), which must be proportional to the absolute temperature. We have already seen that the elastic pressure of a gas should be proportional to the molecular repulsion (F). Now for the range of pressure for which the law of Mariotte holds good, we have

$$\mathrm{F}=f=\frac{m}{x^2}=\frac{m'}{x'^3}=\frac{\mathrm{C}m}{x'^3}.$$

The volume is represented by x'^3. If x' becomes $x'+dx'$, the volume becomes $(x'+dx')^3=x'^3+3x'^2dx'$ (very nearly). Thus the increase of volume is $3x'^2dx'$; and the ratio of increase $\frac{3x'^2dx'}{x'^3}$. But the increment dx' is due to an increase of temperature, and must answer to dm, while f remains constant. Thus $dx'=\frac{dm'}{3fx'^2}$, and therefore the ratio becomes

$$\frac{dm'}{fx'^3}=\frac{dm'}{m'}=\frac{dm}{m}.$$

For the case in which the volume is constant, while the temperature rises,

$$df=\frac{dm'}{x'^3}\text{; and }\frac{df}{f}=\frac{dm'}{fx'^3}=\frac{dm'}{m'}=\frac{dm}{m}.$$

Thus the ratio of the increase of volume is equal to the ratio of the increase of elastic pressure. We may assume that from a certain absolute temperature, T, m increases uniformly for each increment, 1° of temperature. Let t denote the actual temperature above T; then $m=c't$, and $\frac{dm}{m}=\frac{dt}{t}$. From which it appears that above T the increase of volume, or of the elastic pressure, takes place uniformly; that is, is equal in amount for equal increments of temperature. We may conclude from this investigation that Gay Lussac's law holds good only for that range of pressure and temperature within which the law of Mariotte is fulfilled; and that it is not strictly true for the more compressible gases and vapors, except at temperatures considerably above the point of condensation.

Specific Heat of Gases.—When the temperature of a gas is raised 1°, without change of volume, the heat is expended in exalting the vibratory state (i. e. the dynamic energy) of the molecular envelopes, and in augmenting their potential energy by expansion. It is obvious, then, that the specific heat of a gas, under a constant volume, should be some function of the ratio, k, since upon this must depend at a given temperature, the number of molecules in the unit of volume, and the mechanical condition of each molecule. The theoretical indications are that the specific heat of different gases, for the unit of volume, is directly proportional to the value of k; but as these cannot be adequately presented here we will assume this as an hypothesis and test it by the quantitative results to which it leads. To state the hypothesis with more precision, it is that the specific heat of a gas, when the volume is constant and the *initial* elastic pressure is one atmosphere, is, for a unit of volume, proportional to the value of k—it being understood that in the case of a compound gas the value of k considered is that which which obtains when the molecules are in the condition that immediately results from the formation of the gas from its constituents, and at the temperature at which the ratio of condensation is that proper to the gas.

When a gas is allowed to expand under a constant pressure, an additional amount of heat is expended in the work of this expansion in opposition to the external pressure. Now if n were equal to m the amount of heat thus expended should equal that which would be expended on the molecular envelopes. Let U denote the entire amount of heat expended when the pressure is constant, u that expended in the work of expansion, and u' that expended on the molecules directly; and we have $U=u+u'=u+su$. Each term is a function of the temperature, t; and, differentiating, we have $dU=du+sdu$. But we have seen that du equals the value which sdu would have if k, or $\frac{n}{m}$, were equal to unity. Denote it by e, and we obtain $dU=e+se$. But, since the specific heat under a constant volume is proportional to k, $\frac{se}{e}=\frac{k}{1}$; and thus $s=k$. This value of s gives $dU=(1+k)e$, and $sdu=ke$; from which $\frac{dU}{sdu}=\frac{1+k}{k}$. This is ratio of the specific heat under a constant pressure to the specific heat under a constant volume.

Let us now subject these theoretical results to the test of calculation. According to Pouillet the specific heat of aqueous vapor, under a constant volume, is 1·9600, and that of a mixture of one volume of oxygen and two volumes of hydrogen, 0·9277. The ratio of these is 2·113. For aqueous vapor we have seen that $k=4·93$. Thus, $\frac{4·93}{2·113}$ $(=2\frac{1}{3})$ should be the value of k for the mixture of oxygen and hydrogen before condensation into aqueous vapor. This result, as will appear in the sequel, is in accordance with the results of Professor Pictet's experiments on the liquefaction of oxygen and hydrogen.

Taking the specific heat of carbon-dioxide, under a constant volume at 1·26, we have $\frac{1·26}{0·9277}=1·36$, and $1·36\times2\frac{1}{3}=3·17$. This is the value of k for this gas under a pressure of one atmosphere, and in the condition in which it exists as the immediate product of the combustion of carbon. It is here tacitly supposed, in accordance with fact, that the specific heat of the gas, for equal volumes, and under the pressure of one atmosphere, is the same, when in the state of a vapor, at whatever temperature it is supposed to be formed from a liquid. Theoretically there should be a tendency to this state of things, since when the temperature is higher the number of molecules in the unit of volume, at the same elastic tension, is less, but at the same time the specific heat of each molecule should be greater, owing to the increased size of its envelope, and its consequent greater liability to expansion under the operation of the heat energy. For olefiant gas we have $\frac{1{\cdot}553}{0{\cdot}9277} = 1{\cdot}674$; and $1{\cdot}674\times2\tfrac{1}{8}=4{\cdot}2$, the theoretical value of k for this gas. These results enable us to test our expression for the ratio of the specific heats under a constant volume, and at a constant pressure, viz: $\frac{1+k}{k}$. For the mixture of oxygen and hydrogen $\frac{1+k}{k}=\frac{1+2\frac{1}{3}}{2\frac{1}{3}}=1{\cdot}430$. The experimental value is 1·410. For carbon-dioxide $\frac{1+k}{k}=\frac{3{\cdot}17+1}{3{\cdot}17}=1{\cdot}315$. According to experiment it is 1·338. For olefiant gas the ratio is $\frac{4{\cdot}2+1}{4{\cdot}2}=1{\cdot}24$, the same as obtained by experiment. For oxide of carbon I get $k=2{\cdot}60$ and ratio of specific heats $=1{\cdot}38$; experiment gives 1·428. For oxide of nitrogen $k=3{\cdot}396$ and ratio of specific heats $=1{\cdot}294$; experiment gives 1·343.

Professor J. Clerk Maxwell (Nature, March 10, 1875, p. 375) admits that the kinetic theory of gases has encountered a serious dilemma in the attempt to determine specific heats. He says, "We learn from the spectroscope that a molecule can execute vibrations of constant period. It cannot therefore be a mere material point, but a system capable of changing its form. Such a system cannot have less than six variables. . . . But the spectroscope tells us that some molecules can execute a great many different kinds of vibrations. They must therefore be systems of a very considerable degree of complexity, having far more than six variables;" and "every additional variable increases the specific heat, whether reckoned at constant pressure or at constant volume. But the calculated specific heat is already too great when we suppose the molecule to consist of two atoms only." The present theory encounters no such difficulty, since it regards the heat and light vibrations as pertaining to the atoms of the molecular envelopes, and the number of these is indefinitely great, and the determination of the specific heat requires no hypothesis of a definite number of atoms to be made. In the same connection Professor Maxwell has the following remark: "And here we are brought face to face with the greatest difficulty which the molecular theory has yet encountered, namely, the interpretation of $n+e=4{\cdot}9$. He had previously remarked "that $n+e$, for air and several other gases, cannot be more than 4·9. For carbonic acid (?) and steam it is greater." Now $n+e$ answers to the ratio, k, on the present theory, and we have seen (p. 433) that this is 4·93 for steam, and less than 4·9 for the gases.

Diffusion of Gases.—The law of variation of the molecular repulsion, at the distances between gaseous molecules, given by equ. (1), leads to the result that if one layer of such molecules moves over another, so that those on one side of the plane of separation are opposite the vacant spaces between those on the other side, a force of effective repulsion directed toward this plane will supervene, which will operate to diffuse each set of molecules into the volume occupied by the other. Did space admit, we might show that when all the circumstances of the case, and the resistances in operation, are duly considered, the diffusion thus originating should conform to the known laws of diffusion; as that the velocity of diffusion of the individual molecules is inversely proportional to the square root of the molecular weights, &c. The force of diffusion of liquid molecules has a similar origin. Upon this view the force of diffusion is incidental to the inevitable internal agitations occurring in fluid masses; and may be brought into more lively action by artificial disturbances. The molecular repulsive or heat energy consumed in such effects is restored to the mass by the subsidence of the individual movements, perpetually recurring.

Comparison of the present with the kinetic theory of gases.—The theory of gases which has now been deduced from the general expression for the force of effective molecular action (equa. 1, or 2), is no less dynamical in its essential character than the kinetic theory. The dynamical system conceived to be in operation is, upon the one view, the translatory wave movements and atomic vibrations of the interstitial ether and ethereal atmospheres of the molecules, and upon the other, the movements of translation of the molecules themselves, and the vibrations of their constituent atoms. The doctrine of Energy, and the principles of the Mechanical Theory of Heat, are as applicable to the one as to the other theory. The essential correspondence of the two theories is abundantly evident from the fact that with equa. (1) an expression for the elastic pressure of a gas may be obtained that is a counterpart of that given by the equation of Clausius, viz: $p\mathrm{V}=\frac{2}{3}\mathrm{T}-\frac{2}{3}\Sigma\Sigma\frac{1}{2}\mathrm{R}r$. This may be inferred from the general consideration that the impulses upon any point, O, of the enclosure, of an ethereal wave in which the velocity of the radial pulsation increases from zero to a maximum, u, and then decreases to zero, is analogous to the impulse of a gaseous molecule whose velocity, u' is reduced to zero, and then restored in the recoil—the ethereal waves and the gaseous molecules alike impinging on the point from every variety of direction. To show it conclusively, let it be borne in mind that the central atoms of the molecules of the gas may, for each point O, of the enclosure, be conceived to be uniformly distributed over the surface of a hemisphere described around this point, so that each elementary part of the surface will be occupied by one such atom, and so will be a center of radiation of wave-impulses propagated to O (p. 436). Now let u be the maximum velocity of pulsation of the ethereal atoms in any wave, at the point O; m the mass of ether effective in the pulsation; s the minute space (equal to half the length of a wave) over which m moves while the velocity is increasing from zero to u, or decreasing from u to zero; and p_1 the mean impulsive force taking effect over the space s. Then for the wave impulses propagated along the normal at O, $p_1 \times 2s = mu^2$. Let n_1 denote the number of successive waves in the space, 1, and take for the unit of time the interval employed by the wave in traversing the distance, 1; and we have $n_1 = \frac{1}{2s}$ and $p_1 \times 2s \times \frac{1}{2s} = n_1 mu^2$, or $p_1 \times 1 = n_1 mu^2$. But $p_1 \times 1$ is the impulsive work of the waves in the unit of time, and may be taken as p', the force of pressure on an elementary area at O, due to the successive waves propagated along the normal at O. Now for a wave coming from a direction inclined under any angle φ' to the normal, the normal impulse will be $p' \cos\varphi'$, and the normal velocity of pulsation will be $u \cos\varphi'$. Thus $p' \cos\varphi' = n_{,} mu^2 \cos^2\varphi'$; and for n' molecules having this angle of direction, $n'p' \cos\varphi' = n'n_{,} mu^2 \cos^2\varphi'$. For the entire normal impulse at O, or the elastic pressure, p, on an elementary area at O, we have then, $p = \Sigma n'n_{,} mu^2 \cos^2\varphi$. But the gaseous molecules lying in any angle of direction, φ, around the normal, form an elementary zone of the hemisphere, whose breadth is $d\varphi$, and altitude, in the normal direction, $d \cos\varphi$, or $\sin\varphi d\varphi$. If then n represent the number of molecules in the entire hemisphere, $n' : n :: \sin\varphi d\varphi : 1$; and $n' = n \sin\varphi d\varphi$.

$$\text{Thus } p = \int_0^{\frac{\pi}{2}} nn_{,} mu^2 \cos^2\varphi \sin\varphi d\varphi = nn_{,} mu^2 \left(-\frac{\cos^3\varphi}{3}\right)_0^{\frac{\pi}{2}} =$$

$$\frac{nn_{,} mu^2}{3} = \tfrac{2}{3} \cdot \frac{nn_{,} mu^2}{2}. \quad \text{Now } \frac{nn_{,} mu^2}{2}$$

is the entire living force, or energy, of all the ethereal waves occupying at any interval of time the space unity on all the lines radiating from O; or included within a hemisphere traced around O with the radius 1. Calling this E, we have $p = \frac{2}{3}E$. But the hypothesis, which has been tested by quantitative determinations (p. 437), that the repulsive term in equ. (1) varies inversely as the cube of the distance, x', between the centers of the molecules, gives the same law of variation for the impulses received at O; and accordingly if T denotes the value of E, when $x' = 1$, $p = \frac{2}{3}\frac{T}{x'^3} = \frac{2}{3}\frac{T}{V}$, in which V is the volume occupied by a given number of molecules, N, in terms of the volume, 1, occupied by the same number of molecules when the distance between their centers is 1.

If now we take account of the attractive impulses answering to the attractive term in equ. (1), it is plain that by a similar investigation we shall obtain for the diminution, d, of the elastic pressure at O, $d=\frac{2}{3}E'$. Accordingly for the actual pressure on an elementary area at O, we have

$$P=\tfrac{2}{3}E-\tfrac{2}{3}E'=\tfrac{2}{3}\frac{T}{V}-\tfrac{2}{3}E'=\tfrac{2}{3}\frac{T}{V}-\tfrac{2}{3}\frac{T'}{f(V)};$$

where T′ denotes the entire energy of the attractive waves that occupy at any instant a hemisphere described around O with the radius 1. It may be shown that unless the number of atmospheres of pressure be great, $f(V)=\text{const.}\,(V)^{\frac{2}{3}}$, approximately. This expression for P is, essentially, the counterpart to the value of p given in the equation of Clausius (p. 441). The first term is directly proportional to the coefficient of repulsion, m, and so to the temperature reckoned from the absolute zero; and inversely proportional to the volume, V, occupied by a given number of ultimate molecules, N. The other term varies from one gas to another proportionally to the coefficient of attraction, n, and varies for the same gas with the volume occupied by the same number of molecules, N; but does not change with the temperature, except as the volume may vary with the temperature, and the value of n also. In view of the result of this investigation it is hardly necessary to add that all the objections which have been urged against the doctrine that the elastic pressure of a gas is due to statical molecular repulsion are entirely inapplicable to the present theory.

For calculating the gaseous pressure in atmospheres I obtain the formula

$$P_{,}=\overset{\text{atmos.}}{1}\times q\left\{1-\frac{kq\left(3+\dfrac{236}{q^{\frac{1}{2}}}\right)}{13{,}924\left(1+\dfrac{q^{\frac{1}{2}}}{118}\right)^{2}\left(1+\dfrac{q^{\frac{1}{2}}}{59}\right)^{2}}\right\}\left(\frac{288\cdot^{\circ}5+t^{\circ}}{288\cdot^{\circ}5}\right)$$

in which $\frac{1}{q}=$ ratio of the volume, in the case of an ideal gas for which $k=0$ and $\frac{m}{x^{3}}\div\frac{m'}{x'^{3}}$, answering to the assumed value of u, to the volume at the pressure of one atmosphere, and the mean temperature, 15°·5 C., occupied by the same number of molecules; $t^{\circ}=$ temperature above the mean taken as a zero point, $k=$ ratio of coefficients of attraction and repulsion, as before, for the gas and temperature considered. The value of k varies with the temperature. We have already seen (p. 439) that for a certain mixture of oxygen and hydrogen its estimated value is about $2\frac{1}{8}$; and that for carbon-dioxide it is 3·17, when the gas is in the condition and at the temperature referred to on page 438, and increases as the temperature falls, to 4·93 at about the temperature, $-80°$ C. At the critical temperature 30·°9 C., its value is 4·7.

The approximate value of k for any gas at any temperature may be readily obtained, for any other temperature for the same gas, by the empirical law that it is inversely proportional to the $\frac{1}{10}$ power of the absolute temperature. It is to be understood that the calculations are for the value of k at the maximum tension of the gas (vapor) at the temperature considered.

In the liquefaction of oxygen, hydrogen, and nitrogen, when the point of liquefaction, so styled, was reached, the distance, x, between the molecules, must have been reduced to $3{\cdot}5r$, or very nearly this. This distance answers to the point of ebullition of gases whose molecular curve lies just above the critical curve (for which $k=4{\cdot}7$). By specific heat ratios we obtain for oxygen, $k=4{\cdot}93\times\frac{0{\cdot}9765}{1{\cdot}96}=2{\cdot}456$. The reduction of temperature from 15·°5 C. to 145·°5 C. should materially augment this deduced value of k. If we assume that the empirical law holds for oxygen, as for carbonic acid, that k is inversely proportional to the $\frac{1}{10}$ power of the absolute temperature, we obtain $k=2{\cdot}64$. Now taking $u=3{\cdot}5$, I find $q=1156{\cdot}2$. Taking this value of q, and $k=2{\cdot}64$, the formula gives $P_{\prime}=272{\cdot}5$ atmospheres. The volume ratio for the actual gas, for which $k=2{\cdot}64$, I find to be $\frac{1}{650{\cdot}9}$. This gives for the density of the condensed gas, 0·881 the maximum density of water; on the hypothesis that the dimensions of the molecules are unaffected by the reduction of temperature. But theoretically this should be attended with a contraction of the effective molecules. If we assume the law of the consequent diminution in the volume of the gas to be the same as that of the increase of k from a fall of temperature, the density comes out 0·94. According to Professor Pictet's experimental determinations the elastic pressure of the condensed oxygen was 273 atmospheres; and the density 0·98.

If we suppose the original value of k (2·456) to remain unchanged and take $u=3{\cdot}5$, the formula gives $P_{\prime}=285$ atmospheres; and the density comes out 0·936, and after correction for temperature, 1·00. For $k=2{\cdot}6$, and $u=3{\cdot}5$, $P_{\prime}=277$ atmospheres; and the density is 0·91, or 0·975. For $k=2{\cdot}63$, and $u=3{\cdot}5$, $P_{\prime}=273{\cdot}6$ atmospheres; and the density is 0·888, or 0·952.

At the point of incipient condensation of carbon-dioxide, just below the "critical temperature" (31° C.), for which $x=7{\cdot}3r$ I find $q=271{\cdot}14$. With this value of q, and $k=4{\cdot}7$ I obtain $P_1=72{\cdot}2$ atmospheres. Dr. Andrews found the elastic pressure at the critical point to be 75 atmospheres. The small discrepancy results from the fact that the precise critical curve is slightly below that for $k=4{\cdot}7$, and the corresponding molecular repulsion is greater in the ratio of 51, or 52, to 40. Making the correction, we have for P_1 75 or 76 atmospheres.

These two examples must suffice for the present as illustrations of the applicability of the formula, and verifications of its accuracy.

From the point of view I have taken, chemical combinations consist, essentially, in changes effected in the condition of the molecules of the constituents, by which they are brought into approximate correspondence, and take up the relative positions suited to that uniform condition, just as a mass of similar molecules in that state would do. The change of state consists simply in the nearer approach of the envelopes to the central atoms of the molecules, or in a recess from them, from which results a change in the value of the ratio k, and in the corresponding curve of effective action. The determining cause of this change is the difference in the mechanical condition of the dissimilar molecules, more or less enhanced by the unequal operation of heat or electricity. The immediate result may be either an expansion of the one molecular envelope and collapse of the other, or a collapse of both incited by a flow of electric ether from the source of heat or electricity. The union of chlorine with hydrogen may be cited as a probable instance of the former, and the combustion of hydrogen as an instance of the latter. When metals are oxidized, or solids undergo combustion, we must suppose there is a flow of electric ether from the solid to the oxygen molecule, and the former molecule expands somewhat while the other contracts to the dimensions answering to the solid condition.

Heat, in its association with molecules, consists of the energy of recurring pulses and vibrations in the molecular envelopes, and has two modes of motion or two dynamical aspects, *radial* and *tangential*. The energy connected with the former, is the origin of its expansive force. The propagation of the latter, in ethereal waves of transverse vibration, constitutes the radiant heat emitted by bodies.

Heat energy may be expended not only in the expansion of bodies, but also in augmenting the potential energy of the individual molecules by enlarging their envelopes. In this way a certain amount of heat becomes latent in the process of liquefaction. A portion of the heat of vaporization is expended in a similar manner. The enlargement of the envelopes here alluded to consists in a recess of the effective envelopes from the central atoms. This should be attended with a certain diminution in the value of r, the distance between the centers of attraction and repulsion posited within the envelopes; and therefore with an increase in the value of $p\left(=\frac{m}{r^3}\right)$. In fact the quantitive determinations I have given, when compared with the results of experiment, indicate that p is materially larger at the same temperature, for liquids and aeriform bodies than for solids. An important tendency of the diminution of the value of r in liquefaction, is to antagonize the expansion directly due to the enlargement of the effective molecules and the attendant diminution in the coefficient n. According as the one or the other of these two tendencies preponderates, the mass will expand, or contract in the act of liquefaction. In the case of any special solid or liquid, the diminution of r with a rise of temperature tends to diminish the expansion, and by increasing p to make the decrement of tenacity less. Any differences in the value of r that may subsist with molecules of different substances, at the same temperature, can only have the effect to alter the positions of the substances on the molecular scale. Any changes or differences that may occur in the value of r, in the case of the gases, will have no effect on the molecular repulsion at those distances, x, for which F, in equ. 1, is sensibly equal to the second term, and therefore, as we have seen, the law of Mariotte holds good; since the repulsion will still be the same for the same actual distance between the molecules. At less distances the tendency should be to alter slightly the deviations from this law.

The value of the coefficient of attraction, n, depends on the excess of the attraction exerted by the central atom of a molecule on its envelope, over the repulsion exerted on it by the condensed luminiferous ether posited between the atom and envelope. The tendency of a recess of the envelope from the atom may be either to diminish, or augment the value of n. It thus may happen that by an increase of n, and a diminution of r, the value of F may be augmented by a certain rise of temperature; as when a bar of wrought iron is heated up to about 400° F. In the case of gases n may change somewhat with the temperature, and in the process of condensation.

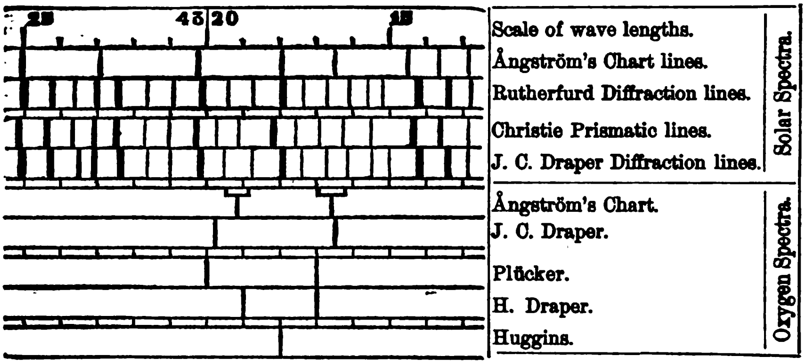
The normal type of solidity is a fixed distribution of the ultimate molecules at the angles of successive cubes; and the fundamental principle of the stability of every such elementary cube is that each molecule is in equilibrium, by itself, with each of the others. As the distances are unequal, this implies that k is smaller in the diagonal direction than in the direction of the sides; and thus that the extension, or physical condition of the envelope is unequal in these directions. It is in this sense that "polarity of atoms" (ultimate molecules) exists. Instead of being an inherent property of the atoms, it is liable to change with varying relations to other molecules. When the mass varies in density from one point to another, there is a gradual variation in the size of the elementary cubes, or a gradual transition from cubes to parallelopipedons, or other geometrical figures, with attendant variations in the curves of effective molecular action. The molecular envelopes of different substances may be liable to different varieties of polar condition under the same circumstances, and so the substances may have different types of solidification, or crystallization. For the cubical system I obtain as the complete expression for the elastic resistance to a minute displacement of a single molecule, $f+2f'+1\frac{1}{3}f''$; in which f is the force of resistance developed between the displaced molecule and that lying in the direction of the side of the cube, by a displacement s, in this direction; f' the force of resistance of a molecule lying in the direction of a face diagonal, for the same displacement s, in this direction; and f'' the corresponding resistance of a molecule in the direction of the long diagonal. The value of the expression is the same in whatever direction the displacement occurs. The expression for the lateral force developed, as well as for the elastic resistance to shearing, in the direction of a side of the cube is $f'+1\frac{1}{3}f''$. For any reasonable suppositions that can be made with regard to the comparative values of f, f', and f'', the ratio of these two expressions lies between $\frac{1}{3}$ and $\frac{1}{4}$. The experimental ratios fall between these limits. The resistance to shearing is due to the diagonal forces.

When a body is heated to the point of liquefaction, the values of f' and f'', considered as resistances to tension, which are always less than f, vanish (that is, the curves fall below the axis of x). There is therefore no shearing resistance; which is one of the distinguishing features of a liquid. When the temperature of the liquid is raised above the point of liquefaction, effective repulsions must come into play in the diagonal directions. These repulsions are the operative cause of surface evaporation; and at the same time originate at the surface the "contractile force" which, by the variations it experiences from the contact of solids, is the determining cause of capillary phenomena.

Yale College, Nov. 30th, 1878.

ART. LVII.—*On the Dark Lines of Oxygen in the Solar Spectrum on the less refrangible side of G;* by JOHN CHRISTOPHER DRAPER, M.D., LL.D., Professor of Natural History in the College of the City of New York.

IN a paper on the lines of oxygen, published in this Journal for October, 1878, the solar lines closely coincident with those of the electric spectrum of oxygen were given. The measurements of the solar lines in that instance were taken from photographs made in March, 1878. Since that time, under more favorable atmospheric conditions, I have succeeded in obtaining finer photographs on the less refrangible side of G. These show many faint lines, not visible in the photographs of March 1878, while many other lines are distinctly sub-divided. Three of the recent photographs were taken on the same day, during the last week in November, and two have been taken since that time; one during the last week in January, and one during the first week in February. In all five of these photographs faint lines are visible between λ 4316 and λ 4320, of Ångström's scale, and they all show them in the position indicated by the diagram and table. The fact that all the photographs agree in their representation of these lines, is, I think, proof positive of the correctness of the positions assigned.



To place the question of the oxygen lines in this region as clearly as possible before the reader, I have devised a diagram which represents the facts regarding this portion of the solar spectrum, together with the wave lengths of the oxygen lines obtained from the electric discharge in air, and in oxygen gas. The final drawing of the diagram was made for me by my assistant, Mr. Sickels, from the wave lengths given in the table at the close of this article. The drawing was on the scale of one centimeter to each wave length. This was photographed down to one-half its size by a photo-engraving operation. From the plate so produced, the diagram was printed. For accurate work the figures in the tables should be employed.

The first space of the diagram beneath the scale of wave lengths gives the positions of the solar lines of Ångström's chart.

The second represents measurements made from one of Dr. Rutherfurd's paper prints of this region. These measurements were made after I received Mr. Christie's paper, with a view to the detection of any difference between Dr. Rutherfurd's photograph and my own.

The third space contains a presentation of the lines of this region as given by Mr. W. H. M. Christie, of the Royal Observatory at Greenwich, in the Monthly Notices of June, 1878. This I did not receive until the latter part of last January, when I was much pleased to find the close coincidences of our results, although they were obtained by entirely different methods, and without any knowledge of each other's work. Line by line Mr. Christie's map is the counterpart of the spectrum I had mapped from the photographs taken during the last week in November, and since that time. Not only do these maps agree very closely in the placing of the lines, but the similarity in intensity is also marked. The presence of these faint lines in Mr. Christie's prismatic spectrum settles any objection that might be raised on the ground of their being interference lines in the diffraction spectrum.

The fourth space presents the measurements of my recently taken photographs. The accuracy of adjustment to Ångström's scale is shown by the coincidences in the lines λ 4312·8 and λ 4325·2. The comparison of this with my reading of Dr. Rutherfurd's photograph, as given above, while it shows slight differences, is a very satisfactory evidence of the reliability of the photographic method of investigating this problem. It is also a refutation of the objections raised by some to my system of measuring and studying the lines of the solar and other spectra. Indeed, with proper lenses, and in competent hands, the process I have followed is not only very reliable, but the apparatus may be truly regarded as an instrument of precision. Of these I hope to give ample proof hereafter.

The position of the lines in this region of the solar spectrum being established by three independent observers, and the question of primary importance, as Mr. Christie justly calls it, settled; we pass to the examination of what these lines probably represent. First: Oxygen. Beneath the four charts of the solar spectrum, I have placed five sets of measurements of the oxygen lines in the vicinity of G. Beginning below, Huggins gives a single line at λ4318. The other observers all divide this, H. Draper places the two branches at λ4317 and λ4319; Plücker at λ4317 and λ4320. My own readings are at λ4316·50 and λ4319·75. Those of Ångström's chart are at λ4316·57 and λ4319·15.

In the above measurements, those for the more refrangible line are all within one-half of a wave length. The readings of the other line are within one wave length. In these positions there are, therefore, oxygen lines, and in the same regions of the solar spectrum, Dr. Rutherfurd, Mr. Christie, and myself, agree in finding faint dark lines. More than this; granting that the forked symbols of Ångström's chart indicate, (and I cannot understand what else they mean) that the observer believed that the line λ4316·57 is divisible into two lines, placed at λ4316·20 and λ4316·95, and the line λ4319·15, into two, placed at λ4318·85 and λ4319·45, we find that the three charts of the solar spectrum gives lines which are very nearly coincident with the readings of these forked symbols. It is not often that the results obtained by so many independent investigators agree as closely regarding a problem to be solved only by observation and experiment, and considering the smallness of a wave length, and the difficulty of making such measurements, the agreements must be regarded as favoring strongly the identity of these feeble lines of the solar spectrum with the lines of the electric spectrum of oxygen.

Among the obstacles in the way of comparing the electric lines of oxygen with those of the solar spectrum, and which in part explains the discrepancies that exist in the measurements of the lines of oxygen, is the difficulty in making exact measurements of these lines. Of this difficulty Plücker speaks in a memoir on the oxygen spectrum in the Phil. Trans. for 1865. In the same memoir he also discusses the variation in the breadth of the lines, and the variation in this variation, in different parts of the electric spectrum of oxygen. The positions given by Plücker and myself agree closely, although he gives no fractions. We both used two prisms of flint-glass, though at times he used four. Plücker's results, and my own, were obtained in pure oxygen gas, while those of H. Draper, and of Ångström's chart, were from the electric spark in air. This may possibly explain why they agree in differing slightly from Plücker and myself.

In the measurement of the lines of the solar spectrum made by Mr. Christie, the spectroscope was, he says, equal in dispersion to fifteen prisms of 60°. Dr. Rutherfurd's photographs and mine were made by means of Rutherfurd's gratings of over 17,000 lines to the inch, mine being by reflection and in the second order. The great dispersion thus brought to bear upon the solar spectrum, is, I think, the explanation of the subdivision in that spectrum, of the electric oxygen lines given as two, by Plücker, H. Draper and myself. I do not know what the dispersion power was, nor the exact electric conditions that gave the forked symbols of oxygen in Ångström's chart; but whatever the dispersion, and whatever the electric, and consequent thermal or other condition, they seemed to have produced results very close in their relation to those in recent photographs of the solar spectrum.

Discussing the existence of bright lines of oxygen in the solar spectrum at λ 4317 and λ 4319, Mr. Christie directs attention to the opposing fact, that the spaces at λ 4315 and 4321·5 on Dr. Rutherfurd's photograph are both brighter than those at λ 4317 and λ 4319. This is also shown by my photographs, in which the slit was sufficiently narrow. I may add, that there are in my photographs, and in that of Dr. Rutherfurd, in the region from 4290 to 4301, many lines brighter than any in the spaces mentioned. Accepting these as being the true measures of brilliancy of the bright background of the spectrum in this region—and there is no reason why we should not do so—we are justified in saying, that from λ 4314 to λ 4322, and particularly in the vicinity of λ 4317 and λ 4319, there is something in the solar envelopes, which by absorption, reduces the brilliancy of the spectrum. In addition there are also faint lines which occupy the positions of certain electric oxygen lines.

If these faint dark lines are not the result of the action of oxygen, to what other cause are they to be attributed? Besides the well marked lines of calcium and titanium, no one places lines of any element here except Huggins, who claims a weak strontian line at λ 4319, and a carbon line as given at λ 4320, in Watts' Index. The space from λ 4315 to λ 4318 is free from any claimant, and here there are lines, representing the position of the line of oxygen, upon which nearly all the measurements closely agree. It appears to me that this want of any other explanation, is a fact of importance by no means to be overlooked, in arriving at the true solution of the problem of the oxygen lines.

In the table, the wave lengths of all the lines of the solar spectrum in this region are given, according to Ångström's scale. In Dr. Rutherfurd's photograph, I think, several of the lines are subdivided, according to the figures presented in the last column. An inspection of the original photograph of the spectrum itself is required to decide this matter, as the enlarged paper print in my possession is not entirely satisfactory, giving only the appearance of subdivision as I have recorded.

Conclusions.—1st. The regions in the solar spectrum at λ 4317 and λ 4319 claimed as bright lines of oxygen, are not as bright as others in their immediate vicinity.

2d. The solar spectrum shows faint dark lines in the region about λ 4317 and λ 4319.

3d. Oxygen is the substance which can produce dark lines in this region, therefore we must attribute them to the presence and action of that element.

Ångström's Chart Elements.	Solar Spectra.				Oxygen Electric Spectra.					Additional Subdivisions. Rutherfurd's Photograph.
	Ångström Chart.	Rutherfurd.	Christie.	J. C. Draper.	Air. Ångström.	Oxygen. J. C. Draper.	Oxygen. Plücker.	Air. H. Draper.	Huggins.	
	4312·85	4312·8^{4}	4312·85^{1}	4312·85^{4}						
Ti	13·67	13·4^{8}	13·60^{7}	13·40^{9}						
Fe	14·50	14·2^{10}	14·35^{9}	14·20^{10}						14·0^{6} 14·2^{9}
		15·2^{1}		15·00^{0}						
		15·6^{0}	15·50^{1}	15·45^{0}						
		16·1^{3}	16·25^{3}	16·15^{3}	16·20					16·0^{3} 16·2^{2}
	16·50	16·7^{1}	16·90^{0}	16·72^{1}	16·95	16·50^{8}	17·00^{6}	17·00^{8}		16·5^{1} 16·9^{0}
		17·3^{1}	17·55^{1}	17·40^{1}						
Ca	17·95	17·9^{9}	18·15^{8}	17·95^{9}					18·00^{6}	17·8^{7} 18·0^{3}
		18·7^{2}	19·10^{1}	18·75^{2}	18·85			19·00^{8}		
		19·4^{1}	19·70^{1}	19·50^{0}	19·45	19·75^{8}	20·00^{8}			19·2^{1} 19·6^{1}
Ti	20·25	20·1^{8}	20·25^{8}	20·13^{8}						20·0^{5} 20·2^{5}
		20·9^{4}	21·03^{4}	21·00^{3}						20·8^{4} 21·0^{1}
		21·6^{1}	21·70^{0}	21·65^{0}						
		22·4^{2}	22·50^{8}	22·23^{9}						22·3^{7} 22·6^{6}
Ti	22·90	23·0^{7}	23·10^{7}	23·10^{8}						
		23·6^{4}	23·70^{5}	23·50^{6}						
		24·2^{7}	24·40^{9}	24·25^{9}						
Fe	25·05	25·0^{10}	25·18^{9}	25·03^{10}						24·8^{9} 25·2^{9}

The value 0 is given to exceedingly faint lines.

ART. LVIII.—*On the Genesis of Cinnabar Deposits*;*

by S. B. CHRISTY, Ph.B.

THE study of the origin of mineral veins has developed no fact more clearly than the great importance as a transforming agent of solutions of the alkaline sulphides and carbonates. A constantly increasing number of geological phenomena are being explained by their influence, and the importance which was given to the sublimation theories by the older geologists is gradually diminishing.

The ores of mercury, however, partly from the fact that they have been but little studied, and partly from the ease with which they are volatilized, together with the difficulty of accounting for their solution in any of the reagents which exist in nature, have generally been regarded as formed by sublimation. Even in so recent a work as that of M. H. Kuss, (Mémoire sur les Mines et Usines d' Almaden, reprint from Annales des Mines, p. 47), the author says: "We should always recognize in cinnabar the character of a vein substance carried to the surface very probably in a state of vapor."

The purpose of the present paper is a discussion of the two theories as to the formation of cinnabar deposits. We shall endeavor to find an answer to the question, "Are cinnabar deposits produced by sublimation, or are they deposited from solution?" In considering this question, it will be necessary to briefly review the facts to be explained, and the present state of knowledge of certain of the compounds of mercury. The subject will therefore be divided as follows:

First. The facts to be explained—a brief synopsis of the nature of some of the more important cinnabar deposits.

Second. Some of the more important properties of cinnabar.

Third. The results of some original investigations upon this subject.

Fourth. A comparison of the relative probabilities of the two theories.

FIRST.—THE CHARACTERISTICS OF SOME OF THE MORE IMPORTANT CINNABAR DEPOSITS.

I begin with the deposit with which I am personally acquainted, that of New Almaden. This has already been well described by Professor Silliman in this Journal, but a statement of its principal points may not be out of place.

The New Almaden quicksilver mine is situated about thirteen miles southwest of San Jose, California, in a low range of hills. This range begins at the Hacienda Creek and runs parallel to the Coast range for about four miles, where it is cut by the Guadelupe Creek. These hills, so far as exploited, are composed of serpentines overlaid by magnesian schists which are nearly always black. On analysis they were found to contain, besides silicate of magnesia, a great deal of iron and considerable alumina. Overlying these are other schists, which become more and more aluminous, until finally they change into clay slates. These latter rocks are everywhere greatly metamorphosed, in some cases so much so, that they approach the darker ferruginous varieties of jasper both in appearance and hardness. All of these overlying schists have the same general dip as the surface of the hills themselves, modified of course more or less by subsequent erosion. The serpentine gave as the result of qualitative analysis, large amounts of magnesia and silica, with smaller amounts of iron and alumina, and traces of chromium, manganese, calcium and nickel.

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* A paper read before the Geological Section of the California Academy of Sciences, Dec. 14, 1878.

Lying between these magnesian schists, to which the Mexican miners have given the name "Alta," and the Cornishmen "Hanging Wall," and the serpentine beneath is found the deposit of cinnabar. The "vein matter" itself appears to be a serpentine somewhat altered by infiltrated waters. It is sometimes extremely hard and tough and difficult to mine; at other times it is soft and fragile. A qualitative analysis of a specimen of the former kind selected by the mining captain as the hardest rock in the mine proved it to contain besides the cinnabar, the same ingredients as the serpentine itself, viz: hydrated silicate of magnesium, with small amounts of iron, chromium, calcium and nickel.

Associated with the cinnabar are found dolomitic crystals of pearl spar, iron pyrites, chlorite, and extremely seldom crystals of quartz. Another notable fact is the occurrence of a bituminous substance resembling idrialite. This substance is wrongly stated by Mr. Kuss, in the memoir above cited, to be "a veritable coal." It is not a true coal. It sometimes has the external appearance of a soft bituminous coal, but when heated melts and flows like bitumen. Ordinarily it is found in the liquid condition, and flows from the drusal cavities in which it is contained when they are opened. When strongly heated it gives off highly inflammable hydro-carbon vapors, and leaves an intumescent coke which is very light and fragile, and burns with scarcely any ash. Sometimes the schists spoken of are impregnated with a hydro-carbon more like petroleum, as in the 1,500 and 1,600 feet levels of the Randol shaft.

In that part of the mine known as the Cora Blanca, there is a sheet of dolomitic limestone which extends from the top to the bottom of the mine. This lies immediately beneath the Alta in most cases, although some ore has been found above it. It varies in thickness from one to two feet. In analyzing this there was found a very small residue insoluble in the hydrochloric acid, which under the microscope proved to contain fragments of iron pyrites. (The substance had been powdered.)

In the various workings there occurs sandstone, particularly in the Cora Blanca. The sandstones seem always to overlie the "vein matter," though in the latter mine they are sometimes impregnated with cinnabar, and are said to have contained when first opened, some native mercury. The exact position and significance of these latter rocks I have not as yet been able to determine. It is altogether probable, however, that they are more or less local in their origin, being the result of slightly varying conditions which existed during their deposition. Such a supposition would account for the gradual change of the sandstones into slates, which often takes place in such a manner as to make it difficult to determine to which class to assign them.

Native mercury occurs rarely; chiefly in the sandstones of the Cora Blanca, but also in the 1,500 and 1,600 feet levels of the Randol shaft, where it ran out of the shattered Alta upon opening out the vein-matter at places where it was much broken up by faulting.

In many cases the micro-crystals of cinnabar are most intimately mixed with those of dolomite, and occasionally with those of quartz. The cinnabar even when apparently pure to the eye, is so thoroughly impregnated with bitumen that a lump of it when distilled out of contact with the air leaves a carbonaceous residue.

Throughout this interesting mine there are many evidences both of chemical and of mechanical action.

A strongly alkaline spring with free carbonic acid (the New Almaden Vichy spring) is still active at the Hacienda. Occasionally springs with sulphydric as well as carbonic acid are opened by the drifts. In the mine "slickenslides," or surfaces polished as smooth as glass by slipping on each other, are frequently met with; and often large masses of serpentine are broken off bodily and are buried in the superincumbent mass of Alta.

The ore is very irregularly distributed throughout the vein-matter, frequently disappears altogether and reappears in such an uncertain manner that, despite the well established course of the ore body, or rather of the "alta" or "hanging wall," there is required a great deal of skill and judgment for the proper exploitation of the mine.

The Gaudelupe and the now abandoned Enriquita mines appear to belong to the same formation; but it would require a thorough examination of all of this series of mines to trace out this and other interesting questions. I have dwelt thus long upon some of the characteristics of this mine because it is in many respects typical.*

Von Cotta in his *Erz-lager Stätte*, vol. ii, p. 616, gives the following as the characteristics of the principal cinnabar mines of Rhenish Bavaria, Bohemia, Alps, Upper Italy and Spain:

Country Rocks:—Sandstone, clay-schists, trachyte, talcose mica slate, limestone and quartzose mica slate.

Ore matter.—Cinnabar, blende, galena, tetrahedrite, limonite, amalgam, copper pyrites, iron pyrites, silver ores, native quicksilver, horn quicksilver, idrialite, lebererz, magnetic iron pyrites.

Vein filling.—Quartz, hornstone, heavy spar, calc spar, dolomite, spathic iron, gypsum.†

Such a general distribution of carbonates certainly argues against the sublimation hypothesis. With a few exceptions these cinnabar deposits are not in *immediate* relation to igneous rocks, but are nearly always found in metamorphic rocks. In some cases, seven out of sixteen, Von Cotta describes these deposits as veins, the others as in clefts (*klüfte*), layers or impregnations. Usually, with the notable exception of Almaden in Spain, cinnabar does not seem to occur in true fissure veins, but rather to be interspersed in the ore body in a very irregular manner, as is indicated by the term "impregnation."

SECOND.—THE CHEMICAL PROPERTIES OF SOME OF THE SALTS OF MERCURY.

The inquiry here becomes at once limited within very narrow boundaries.

The stable salts of mercury which could exist in any natural mineral waters are very few. The mercuric chloride is at first sight the most probable one, the sulphate not existing in solution except in the presence of a free acid. Still, salts of mercury have been proved to exist in at least one mineral water. In the analysis of the spring "du Rocher,"‡ there is given as a constituent of the water a small amount of mercury. It was very small; the total amount of all the heavy metals, including mercury, estimated together was only 0·008 grams per liter. But the author states that he obtained enough mercury from 500 liters to exhibit it in the metallic state.

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* For another description of this and other deposits in California, etc., with other interesting facts, see "Les Gisements de Mercure de Californie," par M. G. Rolland," Annales des Mines, 1878, and also "Bulletin de la Société Minéralogique de France, 1878; Bull. No. 6."

† For a full description of the deposits of Almaden in Spain, see the article of Mr. Kuss above cited, pp. 10–49, or translation by the writer, pp. 6–19–20.

‡ St. Nectaire-le-haut, Puy-de-Dome, by M. Garigon, Comptes Rendus, vol. xxxiv, p. 936.

It seems much more probable, however, that the salt of mercury usually regarded as the most insoluble is the one in which we are directly interested, i. e. the mercuric sulphide. This salt, while insoluble in almost everything else, is well known to be soluble in solutions of the alkaline sulphides containing free alkali. This fact is recognized both by Rose and Fresenius, but I have been unable to find any exact statements as to the degree of solubility. Prof. V. Stein, in Dingler's Polytechnisches Journal, vol. cxxxviii, p. 390, states: "I found that sulphydrate of sodium as well as potassium dissolved cinnabar even in the cold with the same ease as water dissolves sugar." This statement is, to say the least, a great exaggeration. He also states that the polysulphides of the alkalies failed to dissolve any noticeable trace of the sulphide of mercury. Fresenius* finds that yellow sulphides of ammonium dissolve traces of sulphide, of mercury, particularly in the cold. Barfoed† states that while sulphides of sodium and potassium dissolve mercuric sulphide sulphydrates of the alkalies, as well as sulphydrates to which sulphur has been added, fail to do so.

On the other hand, Dr. R. Weber‡ states that he found that sulphide of potash dissolves the mercuric sulphide only in the presence of free potash or soda. Moreover, that the addition of carbonic acid, sulphydric acid, or flowers of sulphur, precipitates the mercury from such a solution completely.

Again it is well known that the polysulphides of the alkalies change the black variety into cinnabar, which could hardly be the case unless partial solution had taken place. Also, that when mercuric sulphide is slowly deposited from such solutions cinnabar results, but when rapidly deposited as by dilution, etc., the black or amorphous modification; finally, that cinnabar volatilizes out of contact with the air at a little below red heat, depositing cinnabar when slowly cooled, and the amorphous variety when rapidly cooled.

Such in brief is at present the not altogether satisfactory state of knowledge on this subject.

THIRD.—EXPERIMENTS UPON THE SOLUBILITY OF MERCURIC SULPHIDE IN SOLUTIONS OF THE ALKALINE SULPHIDES AT HIGH TEMPERATURES AND PRESSURES.

The great difficulty of accounting for the deposits of cinnabar in the wet way has always been the difficulty of finding any natural solvent for this substance. The experiments of Weber, cited above, show that as soon as the free alkali is neutralized either by carbonic or sulphydric acid the mercuric sulphide is precipitated completely from its solution in the alka-

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[*] Zeitschrift für analytische Chemie, vol. iii, p. 140.

[†] Journal für praktische Chemie, vol. xciii, p. 244.

[‡] Poggendorff's Ann. d. Phys. u. Chem., vol. xcvii, p. 76.

line sulphides; and, as free alkali is not known to exist in any natural mineral waters, the question has still remained, "In what has this substance been dissolved, if we are to suppose it to have been formed in the wet way?"

The classic researches of Daubrée on metamorphism,* and those of De Sénarmont† on the formation of mineral veins in the wet way, as well as the fact that these solutions must have originally acted at higher pressures and temperatures than those of the atmospheric waters, led to the following investigations.

Impressed with the idea that moderate increase of temperature and pressure might possibly bring about the desired results, I was led to adopt a more easily manageable apparatus than that used by the investigators already mentioned.

For this purpose I used a Papin's digester of gun metal, about 7¾ inches high, 3½ inches in outer diameter, and $\frac{5}{16}$ inch thick. This vessel was calculated to stand with safety a pressure of 650 to 700 lbs. per square inch. It was provided with a safety-valve so that the pressure could be easily regulated at any point, and as an additional check it was heated in a bath of iron filings, so that the temperature could be approximately determined. The whole was surrounded by a sheet-iron shell to guard against the danger of explosion. The digester was heated by an ordinary Bunsen burner. The substances to be experimented upon were enclosed in glass tubes usually sealed at both ends, but occasionally open at the top so as to allow the contents to slowly evaporate under pressure, after the water in the digester itself had evaporated through the safety valve.

The only disadvantage of using this form of apparatus was the difficulty of determining when the water was entirely evaporated. This led to several explosions of the sealed tubes within the digester and the consequent loss of many days' work. The joints were all made with a lead packing, as paper, leather, etc., would not resist the high temperatures at which the experiments were conducted. The highest temperatures reached were in the neighborhood of 250° C. (482° F.). The thermometer at the bottom of the bath of iron filings indicated 360° C. and at the top 150° to 200° C.

The first experiment made was with a tube containing amorphous mercuric sulphides with a solution of potassic sulphydrate (potash solution saturated with sulphydric acid.) The tube was open at the top and its contents were allowed to evaporate to half their bulk (after the water in the digester was evaporated) under a pressure of 150 lbs. per square inch. The temperature was about 180° C. The operation was continued five hours. The sulphide was entirely changed to a red powder and the next day the tube was found to contain a beautiful coherent mass of crystals of cinnabar, recognizable by the naked eye, simulating the crystals which occur in nature very perfectly. They appeared to be rhombohedrons, although I have not been able to determine this with certainty.

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* Ann. des Mines, 5 Serie, vol. xvi, p. 155 and 393.

† Ann. de Chem. et Phys., vol. xxxii, p. 129.

Subsequently a large number of experiments were made, all with closed tubes, upon various solutions in contact with amorphous mercuric sulphide, for the purpose of determining the action of these different reagents. The temperatures varied from about 200° to about 250° C., and the pressures from 260 to 500 lbs. per square inch. The determinations of the pressures were not perfectly exact, owing to the difficulty of making the valve-seat bear with perfect uniformity. The duration of the heating varied in the different experiments from three to ten hours, and in each case the digester with its contents was allowed to cool undisturbed till morning.

The results of these experiments are as follows:

Solutions of sodium bicarbonate did not change the amorphous variety of mercuric sulphide to cinnabar. Solutions of water-glass were equally powerless. But when through either of these solutions sulphydric acid was passed, and the tubes were again heated in the digester, the transformation was complete. Polysulphide of potassium as well as sulphydrate changed the amorphous sulphide very rapidly and completely. The presence of excess of carbonic acid seemed to retard the formation without being able to prevent it. The cinnabar formed was usually in the state of micro-crystals, like vermillion, but often they were larger and more like the native cinnabar in appearance, though they were so minute as to make the determination of the crystalline form extremely difficult. In all cases when the transformation had taken place, the liquid would stain the skin deep black, as is usual when mercuric sulphide is dissolved in alkaline sulphides. This would be an additional proof, if one were needed, that solution had taken place.

Finally, I was led to try the effect of heating the amorphous sulphide with the New Almaden Vichy water, to which sulphydric acid had been added. This water as analyzed by E. Piquet, Mining and Scientific Press, vol. xviii, p. 360, has the following composition:

"Bicarbonate of soda	50·3	grains.
Bicarbonate of lime	8·0	"
Sulphate of lime	10·5	"
Sulphate of magnesia	3·0	"
Chloride of sodium	8·4	"
Oxide of iron	1·2	"
Silica	traces."	
Carbonic acid	28·2	"

This amount was contained in a bottle of two pounds.

Sulphydric acid was passed into this water for half an hour, an equal amount of mineral water, and some black mercuric sulphide were added to it, and the mixture was treated in the digester, while a similar experiment was carried on at the ordinary pressure of the atmosphere and a temperature of 100° C. The temperature of the digester was not more than 180° C., and the pressure 140 to 150 lbs. The time in both cases was two hours. The sulphide which was treated in the open air was unchanged even when examined with the microscope, while that treated in the digester was brownish red even to the naked eye, while under the microscope it showed itself to be composed of a small amount of as yet unchanged amorphous sulphide, and a larger amount that was completely transformed to cinnabar. Crystals were not visible with the powers used.

This mineral water, therefore, when the single ingredient of sulphydric acid is added to it is capable of dissolving mercuric sulphide, and of depositing it from solution in the crystalline form when it is slowly cooled.

FOURTH.—THE RIVAL THEORIES.

It would be idle to attempt to follow the mercuric compounds from their existence in the nebulous mists to the ore deposits in which they are found to-day, but it is altogether probable, from the great permanence of the mercuric sulphide, that the mercury salts would be precipitated in that form soon after the waters had been deposited, and that the mercury would be found in that as sulphide in the earliest sedimentary deposits. On the one hand we have the sublimation hypothesis to account for the present position of these ore deposits, and on the other the solution theory. Now, while it is probable *à priori* that as these deposits were buried deeper and deeper by subsequent debris, that the interior heat of the earth would raise them to such a temperature that *if sufficiently extensive fissures were to occur volatilization might ensue*, and the vapors would rise upward to such points as would permit their recondensation; and while it is possible that in special cases as in the vicinity of eruptions of true igneous rocks such may be the case, at the same time *it is probable that the deposits as they exist to-day in situ are the result of the action of mineral waters, which act either by leaching out the cinnabar from neighboring rocks, or more probably by bringing it from lower rocks.*

In support of this position are the following facts: In the first place, cinnabar volatilizes only at just below a red heat (500° C.), when exposed to the ordinary pressure of the atmosphere. Now, if we take the increase of temperature as 1° C. for each 100 feet below the surface, it would take a depth of nearly

50,000 feet to give this temperature. At New Almaden, for example, which is certainly not in the immediate vicinity of volcanic rocks, since the cinnabar outcrops upon the summit of the hills, we should have to assume an erosion to have taken place of nearly nine and a half miles of strata. The age of the formation (pronounced Cretaceous by Prof. J. D. Whitney, in the Geological Survey of California), hardly admits of such an hypothesis. On the other hand it is impossible that the foldings, etc., due to mechanical action, occurring as they usually do so gradually, could have given rise to the necessary temperature. And even assuming that at the time of the formation there was a rate of increase of temperature with depth three times as great as at present, it would still require a depth below the surface of three miles to give such a temperature.

Not only so, but at such a depth the enormous pressure of superincumbent strata would greatly increase the heat necessary for sublimation. This fact is well illustrated by the case of water. The natural rate of increase of temperature due to internal heat can never be great enough to convert water into steam except by the presence of local igneous rocks. Pfaff, in his Geologie als Exacte Wissenschaft, p. 112, shows this by the following table.

Depth in feet.	Temperature. Centigrade.	Pressure of water in atmospheres.	Tension of steam in atmospheres.
10,000	100	300	1·
20,000	200	600	15·3
80,000	800	2400	1416·
100,000	1000	3000	1877·
200,000	2000	6000	2403·

The third column gives the weight in atmospheres of a column of water of a height equal to the depth; this is the minimum pressure to which it can be exposed, unless we suppose an extensive fissure filled only with air and extending far upward. The fourth column gives the tension of steam at the temperatures corresponding to the depths calculated according to Regnault's formula. It is evident that under these conditions the water will never boil at any depth except in cases of local eruptions of volcanic rocks. Although there have not been, to my knowledge, any determinations of the elastic force of cinnabar vapor, it is probably less than that of steam, and the above reasoning will apply with even greater force to this case.

In the second place, the deposits themselves, as indicated in our study of the principal cinnabar deposits, do not usually show the signs of true fissure veins, but are rather found irregularly disseminated in layers and impregnations; nor are volcanic rocks usually found in sufficient proximity to give the heat necessary for volatilization.

In the third place, the formation of many of the ore bodies cannot be explained upon the sublimation hypothesis. Many of them, notably that of New Almaden, contain carbonates so intimately mixed with cinnabar that the conclusion is inevitable that they were formed in the same, i. e. in the wet way. The occurrence of quartz and bitumen intimately mixed shows the same thing.

Again M. Kuss* himself, though evidently inclined toward the volatilization theory, admits that: "The material of the quartzite which is lacking to-day in the rocks impregnated with cinnabar, certainly could not have been missing either at the time of the first deposit of the beds or after the strong pressure which compressed and straightened them. How could this disappearance of siliceous matter be effected, matter almost inattackable by all the reagents which we can imagine to have intervened during the epoch of the formation of the veins of cinnabar?" This disappearance of siliceous matter is certainly inexplicable by the sublimation hypothesis; but by the supposition that the cinnabar was deposited from solution in a mixture of alkaline sulphides and carbonates, it is not only explained but also would be a perfectly natural consequence of the main supposition.

Still again, of the minerals which were mentioned in the first part of the paper as accompanying cinnabar, all, with the possible exception of magnetic iron pyrites, have been produced in the *wet way* by various experimenters as the following references will show.

Blende, by De Sénarmont, Ann. Ch. Phys., xxxii, 129.
Galena, by De Sénarmont, Ann. Ch. Phys., xxx, 139.
Fahlore minerals, by De Sénarmont, Ann. Ch. Phys., xxxii, 129.
Iron pyrites, by De Sénarmont, Ann. Ch. Phys., xxx, 140.
Horn quicksilver, in many ways.
Quartz, { Daubrée, ibid.
De Sénarmont, Ann. Ch. Phys., xxxii, 129.
Heavy spar, De Sénarmont, Ann. Ch. Phys., xxxii, 129.
Dolomite, Hunt, Am. Jour. Science, II, xxviii, 170, 365; xlii, 49.
Spathic iron, De Sénarmont, Ann. Ch. Phys., xxx, 153.
Gypsum, Hunt, Compt. Rend., xlviii, 1003.
Calc spar, { Becquerel, Compt. Rend., xxxiv, 29, xxxvi, 207.
Rose, Pogg. Ann., xii, 533.

The production of bituminous material similar to idrialite has been accomplished in the same way, by heating organic matter with water in closed tubes at high temperatures.† In fact this transformation is invariably regarded not as the result of *dry distillation*, but as the effect of heat in the presence of water. And if the temperature were great enough to have volatilized cinnabar, it is probable that these much more volatile hydrocarbons of the original organic matter would have disappeared, and we should have anthracite or graphite instead of bitumen, as we do in most of the cinnabar deposits.

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* Memoire sur les Mines et Usines d'Almaden, p. 44. Translation of same by writer, p. 21.

† Daubrée, Metamorphism, Annales des Mines, 5th series, vol. xvi, II, end of chap. iv.

In addition to this we have shown that the sulphide of mercury at comparatively moderate temperatures is soluble in solutions of the alkaline sulphides, *that increase of pressure aids rather than retards this solution*, and that cinnabar is deposited from such solutions in the crystallized form when the temperature and pressure are slowly lowered. We have shown that by adding sulphydric acid to the mineral spring water, now existing in the neighborhood of one of the most noted of these deposits, we were enabled to produce the same effects. For various reasons, which it is unnecessary to state here, it is probable that this spring once contained sulphydric as well as carbonic acid, and we have, consequently, in the case of the New Almaden mine, sufficient cause at least for the deposit without invoking the sublimation theory.

Again, the occasional occurrence of metacinnabarite is easily explainable by the sudden dilution of the depositing waters by waters of other springs, by water from above, or by the local mixing during the crystallization process with carbonic or other acid gases. Such a mixture of amorphous sulphide with minute crystals of cinnabar, as described by Moore, (Ueber das Vorkommen des amorphen Quecksilbersulfids in der Natur) is easily reproduced by any of these methods. No other theory so well accounts for the intimate mixture of the two varieties; for the amorphous product produced by suddenly cooling the vapor presents an entirely different appearance.

Finally, the almost universal occurrence of these deposits in metamorphic rather than in igneous rocks, accords well with the theory that *these deposits as they exist in situ are the immediate result of the action of solutions of alkaline carbonates containing also alkaline sulphides.*

There are still many other points of interest in this connection which are difficult to understand. Such, for example, are the wide spread association of serpentine and other magnesian rocks, and of the bituminous substance idrialite with cinnabar. It is possible that these are conditions as well as mere concomitants. Lastly, there remains the occurrence of native mercury to be explained. Unless we regard it as the effect of the local oxidation of a very stable compound, its appearance is well nigh inexplicable upon either hypothesis.

University of California, Berkeley, Dec., 1878.

ART. LIX.—*Notice of Recent Scientific Publications in Brazil.—O. A. Derby on the Geology of the Lower Amazonas;* by RICHARD RATHBUN.

THE Archivos of the National Museum of Rio de Janeiro, which were started in 1876, and of which only a single volume was published regularly, have again made their appearance. The numbers recently received, and issued only in the early part of this year, comprise volume II complete, for 1877, and the first half of volume III, for 1878. They are accompanied by numerous plates, some of which seem to have been carefully executed. The cause of the delay in the publication of this annual, the only one devoted to natural history memoirs in Brazil, is not given, but the high character of several of the articles contained in the present volumes, partially compensates for their late issue.

Dr. Fritz Müller, of Santa Catharina, contributes to both volumes interesting papers on certain structural points among insects, principally on the scent-bearing organs of several species of Lepidoptera, and, in volume II, treats of the correlation of the versicolored flowers of a species of *Latana*, of Santa Catharina, and the insects which fertilize them. Dr. Lacerda, of the Museum, gives the results of his experiments with the poison of *Bothrops jararaca* and *Bufo ictericus* on several domestic animals. The second volume also contains "Notes on the Localities of Antiquities (Ceramios) of Pará," by S. Ferreira Penna, and an extended memoir, entitled "Notes on the Stone Lip-ornaments of the Archæological Collection of the National Museum," by Dr. Ladislau Netto, the director of that institution. In the third volume are two short geological and mineralogical studies of small sections in the province of Minas Geraes, by members of the School of Mines of Ouro Preto.

The paper of greatest interest to North Americans, however, is "A Contribution to the Geology of the Lower Amazonas,"* by Mr. Orville A. Derby, formerly of the Geological Commission of Brazil, but recently appointed geologist in the National Museum at Rio de Janeiro. This memoir, which occupies considerable space in volume II, is a résumé of the principal results of the explorations of the late Prof. Ch. Fred. Hartt, Mr. Derby and others, in the Amazonian valley, and adds many important facts and generalizations to those hitherto published.

The first portion of the paper is devoted to a discussion of the topography and hydrography of the basin of the Amazonas, and of the relations of the great river and its many large tributaries to the surrounding table-lands and mountain chains, which direct their courses. Mr. Derby endeavors to show that between the three sections of the Rio Amazonas, popularly called the Marañon, Solimões and Baixo Amazonas, or upper, median and lower courses, there exist not only topographical differences, but also very marked differences in geological structure. After briefly describing the general geological history of the Amazonian region, as brought out by Prof. Hartt, the author enters into a detailed account of the several formations, that have been discovered in the lower valley, the immediate subject of his article. The most important conclusions recorded by him are the following:

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* The English version of this paper was published in the Proceedings of the American Philosophical Society of Philadelphia, for February, 1879.

The metamorphic deposits composing the plateau and mountain range between Guayana and Brazil, and the central Brazilian plateau, and thus bordering the Lower Amazonian basin on the north, and forming its higher lands on the south, may be divided into two series—a lower one, consisting of highly crystalline rocks, and an upper one, of generally non-crystalline rocks. The former, which constitutes the most of the Guayanian plateau, and forms the base of that of Brazil, consists of gneiss, gneiss-granite and syenite, and has been referred by Prof. Hartt to the Laurentian. The Serra do Mar and the Serra do Mantiqueira, farther south in Brazil, are made up of the same formation.

The second or upper series, composed mostly of quartzites, metamorphic schists and crystalline limestones, probably represents both the Huronian and Lower Silurian, as an apparent difference in age is exhibited in the exposures of these rocks. To the Lower Silurian are referred, as before, the itacolumites and talcose schists of Minas Geraes. The metamorphic rocks are generally well exposed in the falls and rapids of the several tributaries of the Amazonas, the upper, or non-crystalline series being usually the first reached in ascending these rivers.

The southern edge of the metamorphic deposits of the Guayanian plateau, beginning near the Atlantic, in about 1° north, extends a little south of west to near the confluence of the Rios Negro and Branco, between latitudes 1° and 2° south; the northern edge of the same rocks in the plateau of Brazil presents a line of exposures, which pass the Tocantins, between 3° and 4° S., the Tapajos, between 4° and 5° S., and the Madeira, between 8° and 9° S. The edges of the metamorphic regions, thus defined, mark approximately the borders of the ancient channel, which existed between the primitive islands of Brazil, and in which were laid down, without great changes of level, or disturbances, the newer formations from the Upper Silurian to the Cretaceous inclusive.

There is a certain concordance in stratification between the beds of the two series of the metamorphic deposits, but the evidence goes to prove that the older, or Laurentian, had been more or less disturbed and metamorphosed, before the deposition of the newer, although the great general movement of upheaval, that affected, and gave character to, the entire metamorphic region of Brazil, was posterior to both.

The formations above the metamorphic, so far observed in the Lower Amazonian valley, are the Upper Silurian, Devonian, Carboniferous, Cretaceous and Tertiary. The Upper Silurian immediately follows the metamorphic series, on the north side of the valley, but has not yet been recognized to the south of the Amazonas. On the Rios Trombetas, Curuá and Maecurú, where they were examined by Mr. Derby and his party, the rocks of this formation are exposed over an area of only a few miles in width, have an estimated thickness of about 1,000 feet, and rest upon felsite and syenite; they are very gently inclined, and consist mostly of thin-bedded, argillaceous and micaceous sandstones, with some massive beds of pure sandstone. In the lower part of the series, on the Trombetas, are fossiliferous beds, containing in addition to other species, *Arthrophycus Harlani* Hall, *Lingula cuneata* Con., *Orthis hybrida* Sow. and *Bucania trilobata* Con., which indicate an horizon corresponding to the Medina Sandstone of the Niagara group of North America.

The Devonian rocks occupy a broader superficial area than the Upper Silurian, but, so far as studied, are of less thickness,—about 530 feet. They have been traced northward from Ereré, where they were first discovered by Prof. Hartt, in 1870, a distance of about seventy-five miles, on the Rios Maecurú and Curuá. Three sections or groups were readily distinguished, differing from one another, both in lithological characters and in fossils. The lower, or Maecurú group, having a thickness of about thirty feet, consists entirely of coarse sandstones, and is very fossiliferous. The only fossils of this section that have been determined are the Brachiopods, which prove that the section is closely related to the Upper Helderberg of North America, but has also many characters in common with the Hamilton group.

The second or Ereré group has an estimated thickness of about 200 feet, is made up mostly of fine-grained micaceous sandstones, with some beds of black shale, and is underlaid by beds of cherts. The fossils, which are mostly Brachiopods, are in part identical with those of the Maecurú, in part, with those of the Hamilton group of North America. The upper group, called the Curuá, is about 300 feet thick, and consists almost entirely of black and yellowish shales, passing at times into shaly sandstones. The only recognizable fossils discovered were *Spirophytons*, apparently belonging to the same species as those described from the Hamilton group of New York.

The Devonian rocks in the Ereré region have suffered greatly by denudation, and are much dislocated and divided by trap dykes, making their study very difficult. Beds apparently of Devonian age have been found as far west as the Rio Uatumá, and, to the south of the Amazonas, on the Tapajos and Xingú.

Of all the Paleozoic deposits of the Amazonian valley, the Carboniferous is exposed over the largest area, but, at the same time, presents the greatest difficulties to study. Being composed for the most part of soft rocks, it has been much denuded only widely-separated exposures remaining, of which it is difficult to determine the correlation of the several beds. It is, therefore, also impossible to estimate with certainty the thickness of the series, which probably exceeds 1,800 feet. The rocks are soft sandstones, shales and limestones, of which the latter, though having the least thickness, are the most important, from their being the best preserved and the richest in fossil remains. The fossiliferous beds, originally studied by Prof. Hartt and Mr. Derby on the Tapajos, were traced to the north of the Amazonas, on the Rios Maecurú, Curuá, etc. The different exposures, however, appear to represent about the same limited horizon, characterized by identical fossils.

The region over which the Carboniferous has been actually observed, is defined by Mr. Derby as follows: On the south side of the valley, it reaches up the Tapajos, to near the base of the rapids; westward it extends to, or beyond, the Rio Mauhé-assú, situated midway between the Tapajos and Madeira, and eastward to, or beyond, the Xingú. To the north of the Amazonas, it stretches some distance northward of the region of Alenquer, partially covering up the Devonian between Ereré and the Maecurú locality, and has been found to the west, on the Rio Uatumá, and to the east, on the Rio Jauary near Prainha. There can be no doubt but that the Carboniferous really extends much farther west, and eastward, to near the Atlantic. From what has been said before, however, it will be understood that this formation is not exposed over the entire region above defined, although at one time it must have been continuous there. It was observed on the principal rivers mentioned, generally in the vicinity of the lower falls or rapids, and also at many intermediate localities, but is mostly covered up by more recent formations, or by dense forest growths, and over large tracts has been completely swept away. Notwithstanding the fact that the fossils of this group indicate an horizon, equivalent to the Coal Measures of North America, no seams of coal have yet been found on the Amazonas. The beds lie as a rule nearly horizontal.

Mr. Derby refers the sandstone hills of the Ereré series, which surround the Devonian plain of the same name, to the Cretaceous, from a study of the leaves of dicotyledonous plants, contained in some of the beds. These hills, which are composed of inclined strata, were elevated during, or at the close of, the Cretaceous age, as a broad anticlinal ridge, afterwards denuded away in the central portion, so as to uncover the Devonian plain, and leave the present series of monoclinal ridges, disposed in the shape of an ellipse.

Much of Mr. Derby's paper is also devoted to the extensive Tertiary deposits and the *varzea* of the Amazonian valley, subjects already treated of at some length by Prof. Hartt.

ART. LX.—*First Catalogue of Radiant Points of Meteors*; by EDWIN F. SAWYER.

THE following meteoric radiant points have been deduced from my observations, embracing the recorded paths of nearly 600 shooting stars, seen during the last two years (1877–8) at Cambridge, Mass. Among the number may possibly be found one or two doubtful positions, and a few strongly suspected and probably new showers requiring confirmation. The other positions either confirm those deduced by other observers, and heretofore considered rather doubtful, or are those of old and well established meteor systems. The limits of duration of the several showers are naturally uncertain; the results showing only the observed duration, and not the true period, which important element should receive the closest attention of observers in the future. Considerable complication has arisen from the large number of known radiants, and more attention should be given to establishing and identifying beyond a doubt the true positions of those already catalogued, with their limits of duration, than to the discovery of new and in many cases no doubt pseudo-meteor streams.

The theoretical shifting of the radiant point of a shower from day to day as the earth changes its position, should also, it seems (in the majority of cases), be practically shown in deducing the results; although the approximate character of this class of observations, renders it difficult to notice any shifting of position at intervals of less than a week. This important point should engage the attention of all observers, as going far to demonstrate the period of long enduring showers.

In deducing my results, great care has not only been exercised in regarding the peculiarities of each individual meteor mapped, such as length of path, velocity, magnitude, etc., but

No. (Sawyer).	Dates of Observations.	Radiant point.		No. of Meteors.	Remarks.
		R. A.	Dec.		
1	1878. Dec. 31–Jan. 7.	97½°	+17°	8	Meteors faint and rapid, possibly a new shower. Radiant, very near γ Geminorum.
2	1878. Jan. 29–Feb. 3.	167	+42	7	Quite faint, short and rapid meteors. Confirms Heis (M. 2), 169° + 45°, Jan. 16–Feb. 1.
3	1878. Feb. 24–26.	145	+ 8	5	Meteors very faint, with medium velocity and length of path; one stationary meteor. Denning, from Italian Met. Asso. Obs., 1872, at 147° + 4°, Feb. 1–Mar. 12.
4	1878. March 26–31.	204	+34	4	Meteors quite brilliant and slow, with medium length of path. Evidently confirms Greg and Herschel, at 198° + 32°, Mar. 25–Apr. 24.
5	1877. May 3–7.	223	+21	4	Meteors faint, short and rapid. Denning, at 220° + 21°, April 21, 1874. Radiant near ξ Bootis.
6	1877. June 24–July 3.	287	+25	7	Meteors generally faint, short and quick. Radiant near β Cygni. Denning, at 285° + 32°, June 15–17, 1877. Tupman, at 280° + 29°, June 29–30, 1870.
7	1878. July 28.	337	−33	4	Meteors bright and very slow, with long paths. Herschel, at 339°–34°, July 20–Sept. 20. Seen well by A. S. Herschel, July 28, 1865.
8	1878. July 21–23.	291	+27	7	Meteors faint and quick, with medium length of path. Denning, from Italian Met. Asso. Obs., 1872, at 287° + 27°, July 15–Aug. 2. Compare No. 6.
9	1878. July 23.	285	+49	5	Meteors quite bright, short and slow. Denning, from Italian Met. Asso. Obs., 1872, at 285° + 44°, July 15–Aug. 2.
10	1877. Aug. 10.	43	–56	41	Perseids. Meteors brilliant, with quite long paths. Duration of observation, ¾ of an hour. Horary No. 55.
	1877. Aug. 11.	43	+57	12	Observation from 9.30 to 10.30. Meteors bright and short.
	1878. Aug. 10.	44	+56½	58	Meteors very bright, short and rapid. Duration of observation 1¾ hours. Horary No. 33. Position deduced from one stationary meteor and several short tracks near the focus.
11	1878. Aug. 10.	8	+55	8	Meteors bright, short and rapid. Confirms Denning, at 8° + 53°, Aug. 3–16, 1877. Radiant between α and ξ Cassiopeiæ.
12	1878. Aug. 23–Sept. 1.	282	+42	21	Active shower; meteors bright and rapid, with quite long paths. Mean of 5 positions from Greg's Table, 1876, at 281° + 38°, July 29–Sept. 25.
13	1878. Aug. 25–Sept. 1.	335	+64	6	Meteors generally bright, short and rapid. Greg and Herschel, at 335° + 67°, Aug. 6–31. Schiaparelli and Zezioli, at 340° + 65°, Aug. 28.
14	1878. Aug. 25–30.	237	+65	11	Position well deduced; meteors bright, short and rapid. Denning, from Italian Met. Asso. Obs., 1872, at 235° + 65°, Aug. 24–Sept. 14.
15	1878. Aug. 20–27.	274	+20	7	Short, quick meteors. Denning, from Italian Met. Asso. Obs., 1872, at 270° + 20°, Aug. 24–Sept. 14.
16	1878. Sept. 30–Oct. 2.	23	+17	7	Strongly suspected, and possibly a new shower. Meteors quite bright, short and rapid.

List of Radiant Points.

No. (Sawyer).	Dates of Observations.	Radiant point.		No. of Meteors.	Remarks.
		R. A.	Dec.		
17	1878. Sept. 27–30.	3°	+21°	7	Exact. Meteors bright, short and swift. A new shower. ?
18	1878. Sept. 18–27.	333	+23	5	Rather uncertain. Meteors bright, short and slow. Denning, from Italian Met. Asso. Obs., 1872, at 333°+27°, Aug. 24–Sept. 14.
19	1877. Oct. 28.	356	+40	8	Position exact. Active shower, 8 recorded during ¾ of an hour; early eve. Meteors faint and short. Schiaparelli and Zizioli, at 352°+41, Nov. 13.
20	1878. Oct. 17–22.	28	+33	6	Meteors generally quite bright, short and rapid. Confirmed by H. Corder, Oct. 22–31,? 1878, at 32°+34° Radiant near ε Triangulorum. Possibly new.
21	1878. Oct. 21–22.	47	+27	4	Faint, short and rapid meteors. Greg and Herschel, at 43°+26°. Oct. 18–Nov. 13. Denning, at 47°+28°, Oct. 8; and from Italian Met. Asso. Obs., 1872, at 45°+26°, Oct. 29–Nov. 13.
22	1878. Oct. 20–29.	24	+19	9	Meteors bright, short and generally rapid. Radiant near β Arietis. Gruber, at 21°+22°, Oct. 17–24.
23	1877. Oct. 30–Nov. 11.	30	+21	7	Meteors faint, with short paths. Radiant near α Arietis. Evidently confirms Tupman (94), at 30°+22°, Nov. 3, 1869. Compare No. 22.
24	1877. Nov. 4–11.	60	+18	5	Taurids I. Meteors generally quite brilliant, with medium length of path. Denning, average position at 60°+20°, Oct. 17–Nov. 13, 1877.
25	1877. Nov. 30–Dec. 9.	80	+22	10	Taurids II. Meteors generally quite bright and quick, with medium length of path. Denning, Nov. 25–Dec. 13, at 80°+25°.
	1878. Nov. 26–29.	82	+21	9	Meteors quite bright, generally slow, with medium length of path. Principally seen on Nov. 29.
26	1878. Nov. 24.	330	+63	4	Strongly suspected. Meteors faint, quick and short, and recorded during 1 hour's observation in W. Denning, from Met. Ass. Obs., 1872, at 330°+66°, Nov. 25–Dec. 31.
27	1878. Nov. 23–29.	76	+46	8	Rapid, short and faint meteors. 3 recorded in rapid succession on the 24th. Position exact. Confirms a radiant deduced at Pola, Nov. 27, 1872, at 76°.5+46°.
28	1878. Nov. 24–29.	25	+26	5	Meteors quite bright, short and slow. Denning, from Italian Met. Asso. Obs., 1872, at 24°+27°, Nov. 25–Dec. 31.
29	1877. Dec. 1–9.	97	+16	6	Meteors generally faint, with very rapid motion. Possibly new. Radiant center very near γ Geminorum. Compare No. 1.
30	1877. Dec. 7–9.	54	+35	4	Strongly suspected. Meteors quite faint and quick, with quite long paths.
31	1877. Dec. 28–29.	104	+33	5	Geminids. Meteors faint, short and quick.
&	1878, Dec. 22–26.	102	+35	5	Geminids. Meteors faint, short and quick.
32	1878, Dec. 25.	114	+18	5	Meteors generally bright, short and rapid; all recorded during 1 hour's watch; good radiation. Schmidt, Jan., at R. A., 115° +15°.

during the past year a certain weight has been attached to each meteor mapped, showing the accuracy of the path recorded, on a scale of one to four, and its corresponding value used in deducing the centers of radiation; and the results are believed to be as nearly correct as the number of meteors recorded and the nature of the observations will allow. Observations were taken nearly every fair night in the absence of the moonlight, but were confined principally to the evening hours, between 6 and 11 P. M. The exceptions were morning watches in April, 1878, August, 1877–8, and November, 1877–8, for the appearance of the Lyraids, Perseids, and Leonids. With the exception of the Perseids, these gave negative results; only two or three scattering members from each stream being recorded. The periods of watching each evening varied from one to four hours in duration, and aggregate 187 hours in all. The observations were mostly confined to the eastern quarter of the sky, the few exceptions being watches in the west during the months of August, September and November, 1878.

In deducing the results, the method employed by Prof. Schiaparelli, (i. e. deducing the material obtained from each evening's observations, or those of a few evenings at most), has been used. The positions deduced from less than four meteors (of which there were a large number), have been rejected. In giving weight to the different positions deduced by me, observers should bear in mind that the small number of meteors, recorded in many of the cases, result from one or more of the following causes:

I. The shortness of the period from which each shower is deduced, averaging about five days, the average period of most observers being from twenty to thirty days. II. To the generally unfavorable hours, between which the observations were taken, before midnight, when meteors are much less abundant, than during the morning hours. III. To the small number of hours during which I was able to watch each evening, especially in the spring and winter months; several showers being deduced from one or two hours' watch only.

Corresponding observations of the same meteors are doubtless of great value in determining the heights, etc., of the meteors, as well as their radiant points, and during the latter part of last August, the writer together with Mr. Seth C. Chandler, Jr., made a series of observations at stations some seventy miles apart; the reduction of the same is now being done by Mr. Chandler.

Another series has been partly arranged and carried out by the writer and Mr. Oliver C. Wendell, of Lowell, Mass., and it is to be hoped that other observers will, during the coming year, be found willing to engage in this important work.

ART. LXI.—*Notice of recent Additions to the Marine Fauna of the Eastern coast of North America, No. 5*; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLII.

OF Polyzoa about 140 species have been identified by the writer from the coast between Cape Cod and Labrador. Nearly all these are Arctic or European species, already known. They are mostly described in Smitt's papers on Arctic Bryozoa. They are also mostly enumerated by the writer, in a Check-list of the Marine Invertebrata of this coast, now in type. The following is one of the more interesting new forms.

The recent determination of so large a number of American Polyzoa, confirms the decision already arrived at, several years ago, from the study of other classes, that the fauna of northern New England is remarkably arctic and chiefly of northern origin, and that the fauna of Greenland is more allied to that of Northeastern America than to that of Northern Europe. In a valuable paper* on the Podophthalmous Crustacea of our northern coast, just published, Professor S. I. Smith has arrived at the same results for that group.

Bugulella, gen. nov.

Stems slender, dichotomously branched, consisting of single series of cells (zoœcia), which are connected by short tubular joints that arise medially, from the back and near the distal end of the preceding cell, either singly or two together. Zoœcia elongated, expanded distally, with a large, sunken, elliptical frontal area on the front side, close to the end; gradually tapered to the proximal end, which is united, by an articulation, with the tubular process of the preceding cell, representing the stem. New branches arise laterally from these small joints. Frontal area surrounded by spines. Oœcia subglobular, attached to the distal end of the zoœcia. Avicularia median, at the distal end of the zoœcia, shaped as in *Bugula*. Allied to *Bicellaria* and perhaps to *Brettia*.

Bugulella fragilis, sp. nov.

Zoarium translucent, shining, delicate, filiform, much branched; forming intricate divaricate clusters, sometimes an inch or more in height. Apertures broad oval or elliptical, oblique, with a distinct rim, and with five spines, on each side; of these the two nearest the distal end are much shorter than the other three, which are as long as the breadth of the aperture, and arch over it. Sometimes a median spine is also present at the proximal edge. Ovicells globose, prominent, nearly as wide as the zoœcial apertures, smooth, shining, sometimes sculptured with raised lines, or with rounded sunken areas on the sides. A small oval disk on the lateral surfaces of the zoœcia. Avicularia small, with a rather short, thick, swollen head, the pedicel shorter than the vertical diameter of the head, attached to the distal end of the zoœcia.

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* The Stalk-eyed Crustaceans of the Atlantic Coast of North America north of Cape Cod. Trans. Connecticut Acad., vol. v, Part I, May, 1879.

East of George's Bank, 220 fathoms, on *Acanella Normani*. Presented to the U. S. Fish Commission by the captain and crew of the schooner "Alice G. Wunson."

ECHINODERMATA.

Solaster Earllii, sp. nov.

A large, handsome species. Arms nine in our specimen, elongated, tapering. Upper surface thickly covered with clusters of divergent spinules, mostly six to eight, much smaller and shorter than in *C. papposus.* Marginal plates large, prominent, the largest bearing about twenty spinules, in two transverse rows. Ventral plates with about seven or eight long acute spines in one transverse row. Adambulacral plates with about five shorter, more slender spines. Greatest diameter 180^{mm}; lesser 50^{mm}. Taken in lat. 43° 24′; long. 59° 46′, in 200 to 250 fathoms, by the schooner "Bessie W. Somers," and presented to the U. S. Fish Com. by Capt. Thomas F. Hayden.

Dedicated to Mr. R. E. Earll of the U. S. Fish Commission.

Molpadia turgida, sp. nov.

Body large, elongated, turgid, suddenly tapering posteriorly to the slender, moderately long caudal portion. Tentacles short, almost rudimentary, two-lobed, seldom expanded. Skin thin, often somewhat translucent, dark reddish or purplish brown, filled with perforated table-shaped or spinulated plates, and with numerous regular, circular and oval, biscuit-shaped orange-brown calcareous grains, of various sizes, less numerous than in *M. oölitica*, but far more numerous and more regular than in *M. borealis.* These grains have a concentric structure, either around one, or, when oval, around two nuclei. The perforated plates are rather large and irregular, but delicately formed, much less irregular and larger than in *M. borealis.* They usually have a central circle of three to six foramina, then a circle of ten or more, larger, oval foramina, separated by a thin framework, which runs out into irregular projections beyond the border; the central spinule is elongated, acute, consisting of three or four columns. The largest specimens are about 125^{mm} long, and 25 to 30^{mm} in diameter.

Bay of Fundy,—A. E. Verrill and S. I. Smith, 1865. Massachusetts Bay, 40–100 fath., soft mud, 1877, '78; Gulf of Maine, 1874; Casco Bay, 1873; off Nova Scotia, 1877,—U. S. Fish Commission. Gulf of St. Lawrence, Whiteaves.

ANTHOZOA.

Actinernus, gen. nov.

Body large, short, smooth. The margin below the tentacles is deeply divided into acute lobes, or teeth, continuous with the body-wall. The tentacles are rather large, and adnate to the marginal lobes for a considerable part of their length. Disk large, with the margin undulate or frilled in large specimens. The disk and tentacles apparently are not retractile.

Actinernus nobilis, sp. nov.

Body stout, with a very broad basal disk and short column, and toward the summit thrown into about eight large undulations or folds, bending outward and inward, corresponding to the lobes of the disk; the margin is deeply cut into sharp conical teeth, corresponding to the tentacles in number and position, and like them alternating in an inner and outer row; integument of column and teeth thick, firm and smooth. Tentacles numerous, elongated, tapering, acute, moderately large, subequal, in two rows close to the margin, adnate to the marginal teeth for about two-thirds of their length, or even more. Lips well-developed, with about eight large lobes on each side. Color, in recently preserved specimens, deep purplish brown on the disk and tentacles, with radiating lines of paler color on the disk; mouth deep brown inside; sides of body milk-white, with traces of orange-color where the outer coat remains.

Largest specimens, in alcohol, about four inches broad and three high. Four specimens were presented to the U. S. Fish Commission.

Off Sable I., N. S., 200–250 fathoms, Aug., and Banquereau, about 200 fathoms, Sept. 9, 1878,—Capt. J. W. Collins, sch. "Marion." Eastern slope of George's Bank, in about 220 fathoms,—Capt. and crew of the sch. "Alice G. Wunson," Sept., 1878. Lat. 42′ 31°; long. 64° 20′, 300 fathoms,—Capt. Wm. H. Greenleaf, sch. "Chester R. Lawrence."

Synanthus, gen. nov.

Actiniæ which have a broadly expanded, thin base from which new zoöids arise by budding, so as to constitute a small colony, connected together by a common base. Integument thin and smooth. Tentacles numerous, retractile.

Synanthus mirabilis, sp. nov.

Colonies often consist of five or six, or more, zooids, which are generally parasitic upon the branches of *Primnoa reseda* and *Paragorgia arborea*, often surrounding them like a ligature, and in the case of *Paragorgia* often forming deep constrictions so as to seriously weaken the branches. Column low and button-like in contraction, the integument so translucent as to show the numerous internal radiating lamellæ. Same localities as for the preceding species.

ART. LXII.—*On a new Absolute Galvanometer*; by N. D. C. HODGES.

IN the ordinary form of galvanometer the current is measured by the ratio of the force it exerts on the needle to the directive force of the earth, the ratio being determined by a measurement of the angle of deflection.

The moment of the force with which a unit current acts on the needle may be expressed in a series of the form

$$G_1 g_1 \sin\theta + G_2 g_2 \sin\theta\, Q_2'(\theta) + \text{etc.}$$

where G_1, G_2 are constants depending on the dimensions of the coil, and g_1, g_2 on those of the suspended apparatus, coil or magnet, as the case may be. $Q_1'(\theta)$, $Q_2'(\theta)$ are quantities varying with the deflection.

Only in case all the terms after the first may be neglected are the values of the current proportional to the tangents of the deflections. With a single coil this is not the case. By increasing the number of coils and suitably placing them, the magnetic field may be rendered more uniform.

In reading the deflection either a divided circle or a telescope and scale may be used. With the divided circle the deflection may be as great as 45°, but not more, or else the instrument would not be sensitive to changes in the current. The use of telescope and scale necessitates much smaller deflections. To regulate the strength of the current shunts of small resistance often have to be used; and the proportion of the current through the instrument is rendered doubtful.

If, instead of placing the plane of the coils parallel with the magnetic meridian, they are placed perpendicular to it, the sum of the force of the current and of the directive force of the earth would influence the magnet.

The formula $$\frac{t^2}{\pi^2} = \frac{K}{MT(1+\theta)}$$

expresses the relation between the time of vibration of a horizontal, swinging magnet, its moment of inertia K, its magnetic moment M, and the horizontal component of the earth's magnetic force T.

If this time, the time of vibration without the current, is first taken and then the time $t_{,}$ with the current, we get the relation between the two,

$$\frac{t_{,}^2}{\pi^2} = \frac{K}{M(T+F)(1+\theta)}$$

$$\frac{t^2}{t_{,}^2} = \frac{T+F}{T} \quad \text{or} \quad \frac{t^2 - t_{,}^2}{t_{,}^2} = \frac{F}{T}$$

when F is the directive force of the current on a magnet of unit magnetic moment.

The moment of the force F on the magnet is

$$\begin{aligned} &C\,(G_1 g_1 \sin\theta + G_1 g_1 \sin\theta\, Q_1'(\theta) + \text{etc.}) \\ &= \sin\theta\, C\,(G_1 g_1 + G_2 g_2\, Q_1'(\theta) + \text{etc.}) \end{aligned}$$

θ=the angle between the axis of the coil and of the magnet.

Hence $$C\,(G_1 g_1 + G_2 g_2\, Q_1'(\theta) + \text{etc.}) = F.$$

For the small angles through which the magnet need vibrate, this factor may be considered constant and equals the constant of the instrument, used as a tangent galvanometer, when the deflection is supposed equal to 90°.

Let $G_1 g_1 + G_2 g_2\, Q_1'(0°) + \text{etc.} = K_{90°}$.

Then $F = CK_{90°}$.

The value of C is obtained in the form

$$C = \frac{t^2 - t_{,}^2}{t_{,}^2}\,\frac{T}{K_{90°}}$$

To find the value of $K_{90°}$ the same current, if passed through the instrument used as a tangent galvanometer, will give

$$C = \frac{T}{K\varphi}\tan\varphi$$

Hence $$\frac{T}{K\varphi}\tan\varphi = \frac{t^2 - t_{,}^2}{t_{,}^2}\,\frac{T}{K_{90}}$$

or $$K_{90} = \frac{(t^2 - t_{,}^2)\,K\varphi}{t_{,}^2 \tan\varphi}$$

If the value of K_ϕ is known for any value of φ, the deflection, the constant of the instrument used in this other way is given by this formula.

It is evident that the relative values of K_ϕ for different values of the deflection of a tangent galvanometer may be found by repeated application of this process.

$$K_{90} = \frac{t^2 - t_{,}^2}{t_{,}^2}\,\frac{K\varphi}{\tan\varphi}$$

$$K_{90} = \frac{t^2 - t_2^2}{t_2^2}\,\frac{K\varphi_{,}}{\tan\varphi_{,}}$$

$$\therefore \quad \frac{K\varphi}{K\varphi_{,}} = \frac{\tan\varphi}{\tan\varphi_{,}}\,\frac{t^2 - t_2^2}{t_2^2},\ \frac{t_{,}^2}{t^2 - t_{,}^2}.$$

Any of the usual methods for finding the constant of a galvanometer would also apply.

Physical Laboratory, Harvard College, Feb. 12, 1879.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a New Series of Molecules.*—In 1868, **Angus Smith** made an investigation into the absorption of gases by charcoal, believing that, since this action was on the border line between physics and chemistry, it would throw some light on chemical phenomena. The results then obtained showed that the gases were absorbed in whole volumes, hydrogen being 1, oxygen 7·99, carbonous oxide 6·03, carbon dioxide 22·05, marsh gas 10·01, nitrogen monoxide 12·90, sulphurous oxide 36·95, and nitrogen 4·27. The author has now taken up the subject anew and finds that charcoal does actually absorb gases in perfectly definite volumes, the physical action being like the chemical. Thus calling the volume of hydrogen absorbed 1, that of the oxygen is 8, the proportions by volume being the same as those by weight in chemical union. Moreover, since oxygen is 16 times heavier than hydrogen, charcoal absorbs 128 times more oxygen than hydrogen by weight. Now this number is exactly equal to the density of oxygen squared and divided by two, $\frac{16^2}{2}$, or it is half the product of the density of this gas and its atomic weight. Again, the most probable value for nitrogen is 4·66 volumes absorbed, and hence the weight absorbed is 14×4·66 or 65·3. This number is $\frac{14^2}{3}$, since nitrogen is trivalent. Carbon dioxide is not divided but is simply 22^2. The carbonous oxide absorbed is 6 volumes, the carbon dioxide 6+16=22 volumes, marsh gas 6+4=10 volumes, nitrogen monoxide 8+4·66=12·66 volumes. These figures seem to the author to suggest a new series of molecules, whose weights are produced by squaring the atomic weights and by certain divisions peculiar to the gases in question. It may be perhaps that the larger molecule exists in the free gas and is broken up on chemical combination. The building up of a molecule by volumes in this way suggests the possibility at least that our present molecules may be similarly constructed.—*Proc. Roy. Soc.*, Feb. 6, 1879. *Nature*, xix, 354, Feb. 1879. G. F. B.

2. *On the Reciprocal Displacement of Oxygen, Sulphur, and the Halogens, when combined with Hydrogen.*—**Berthelot** has studied the reciprocal displacements which take place in the so-called hydracids and finds that these also are regulated by the value of the heat of combination. Thus for example, experiment has given him the following equivalent numbers:

$\mathrm{H+Cl}$	$=\mathrm{HCl}$ gas	+22·0	HCl dissolved	+39·3
$\mathrm{H+Br}$ gas	$=\mathrm{HBr}$ gas	+13·5	HBr dissolved	+33·5
$\mathrm{H+I}$ gas	$=\mathrm{HI}$ gas	—0·8	HI dissolved	+18·6
$\mathrm{H+S}$ gas	$=\mathrm{HS}$ gas	+3·6	HS dissolved	+ 5·8
$\mathrm{H+O}$ gas	$=\mathrm{HO}$ gas	+29·5	HO liquid	+34·5

From these numbers it follows: 1st, that Cl should displace Br and I, and Br should displace I, in the hydracids both when gaseous and in solution; this is common knowledge; 2d, that Cl and Br should displace S in hydrogen sulphide either gaseous or dissolved,—also a well known reaction; 3d, that I should displace sulphur in hydrogen sulphide in solution, forming HI dilute; but that S on the contrary should decompose gaseous HI, forming hydrogen sulphide. These facts were experimentally established by placing hydrogen sulphide in a sealed tube containing I, and heating to 500°; no reaction took place. But HI gas on the contrary reacts on S even in the cold, and if the tube be opened under water, the latter rises in the tube, remaining transparent till the inverse reaction takes place in solution, the iodine decomposing now the hydrogen sulphide again, with deposition of sulphur. 4th, that oxygen should displace S from hydrogen sulphide, a common reaction; 5th, that between chlorine and oxygen, an equilibrium should be produced, since on the one side gaseous chlorine should decompose water to form HCl in solution, and on the other gaseous oxygen should decompose dry HCl gas, to form water and chlorine. In proof of this, Berthelot mixed HCl and O in a sealed tube and passed sparks through the tube for several hours with the result, that nine-tenths of the HCl was decomposed, while a similar experiment with water vapor and Cl gave no result. 6th, that O should displace Br from HBr either gaseous or dissolved; and 7th, that oxygen should displace I, under the same circumstances, a fact well shown by the fact that a mixture of four volumes of HI and one of oxygen readily takes fire and burns with a red flame, a good lecture experiment. The inverse reaction does not take place.—*Bull. Soc. Ch.*, II, xxxi, 309, April, 1879. G. F. B.

3. *On the Liquefaction of Hydrogen Silicide.*—Ogier, in the laboratory of Berthelot, has prepared hydrogen silicide pure and has succeeded in liquefying it by means of the apparatus devised by Cailletet. At ordinary temperatures, about 10°, this gas sustained a pressure of 200 to 300 atmospheres without being liquefied. But on sudden expansion, even at fifty atmospheres, the cooling produces a thick mist and droplets appear on the walls of the tube. Under these conditions the gas is evidently very near its critical point. Indeed, cooling it only a few degrees below zero suffices to condense it totally. Under a pressure of fifty atmospheres it is liquid at $-11°$; of seventy atmospheres, at $-5°$; and of 100 atmospheres, at $-1°$. At zero, on the contrary, it remains gaseous even at 150 to 200 atmospheres. The critical point is therefore not far from zero.—*C. R.*, lxxxviii, 236, Feb. 1879. G. F. B.

4. *On the Ytterbia of Marignac, and on a New Element, Scandium.*—Nilson, who was on the point of commencing an investigation of the gadolinite and euxenite earths when Marignac's paper appeared, has proceeded with it since this chemist has given it up for want of material. Having 63 grams of erbia, the

molecular weight of which was 129·25, he sought at first to separate the ytterbia by a modification of Marignac's process, ceasing to heat the melted mass so soon as red fumes appeared. But it proved too tedious and he returned to the unmodified method. After thirteen series of decompositions of the nitrates by heat, there remained a basic nitrate which showed only feeble absorption bands in the green and red. The solution, precipitated with oxalic acid, was evaporated and gave 3·5 grams of a white earth with a scarcely perceptible rose tint, whose molecular weight was 127·64. This low number led the author to suspect the presence of a new element in the ytterbia, and a portion of the chloride was submitted to Thalén who found lines differing from any previously observed in this group. The earth was converted into nitrate, a suitable quantity of sulphuric acid was added, the solution was evaporated, finally over a naked fire, but at such a temperature that the residue dissolved perfectly in water. The molecular weight of the earth diminished gradually until it reached 105·83, and yet traces of ytterbia were present. Examined again spectroscopically by Thalén, it gave twenty-nine lines, the strongest of which had wave lengths of 6078·5, 6054, 6019, 5736, 5729, 5719, 5710·5, 5700, 5686, 5671, 5657·5, 5526, 5089, 5084·5, 5082·3, 4739, 4736·5, 4733. To the element thus established, Nilson gives the name *Scandium*, since the two minerals gadolinite and euxenite in which it occurs are of Scandinavian origin. Its oxide is a colorless earth, the solutions of which give no absorption bands. It is after calcination attacked with difficulty by dilute nitric acid, more readily by hydrochloric. Oxalic acid precipitates it completely. The nitrate is completely decomposed at a temperature at which ytterbium nitrate is only partially converted into a basic salt. Its sulphate is not changed at high temperatures, but is completely decomposed by calcination with ammonium carbonate. Calculated from ScO, the atomic weight cannot be far from 90; though if scandia be Sc_2O_3, the at. wt. would be 135.

The solutions from which the various basic nitrates had deposited were then submitted to examination. The result showed that while the molecular weight of the earth which had precipitated from the solution as basic nitrate continued to diminish, that of the earth which remained in solution remained constantly the same, about 131. Eight of the mother liquors gave a substance whose molecular weight was above 131. Treated again by Marignac's method eight times, these afforded 3·5 grams of an earth of a molecular weight of 131·63, the fused nitrate of which gave only a single feeble erbia absorption band in the green. Repeating the operation, the last traces of erbia were eliminated and the ytterbia obtained pure, its nitrate showing no absorption bands. The erbia of previous authors then is nearly all ytterbia and only a few per cent erbia. The author hopes to study erbia, ytterbia and scandia more carefully, since he has in conjunction with Clève, begun work on ten kilograms each of gadolinite and euxenite.—*C. R.*, lxxxviii, 642, 645, March, 1879. G. F. B.

5. *On an Amidonitrosulphide of Iron.*—Demel has repeated the experiment of acting upon a ferrous solution with potassium nitrite and ammonium sulphide, first noticed by Roussin, in order to study more carefully the product. To prepare the compound, 20 grams potassium nitrite is dissolved in 300 c. c. water, the solution is heated to boiling, 40 c. c. ordinary ammonium sulphide solution is added, and the heating continued for a few minutes. A solution of 33 grams crystallized ferrous sulphate in 200 c.c. water is then added gradually with shaking and the liquid boiled for ten minutes. It is then filtered and the filtrate deposits black needle-shaped crystals, which after recrystallization from water are obtained as brilliant black prisms. They decompose in the air, are easily soluble in water, alcohol and ether, evolve H_2S with dilute and brown vapors with strong HCl, and give off ammonia when boiled with KOH. Even below 100° this body decomposes, evolves heat and leaves ferrous sulphide. Analysis showed that the nitrogen was united partly to oxygen and partly to hydrogen, all the hydrogen being united to nitrogen. The numbers obtained gave the empirical formula $FeSN_2H_2O_2$, from which and the facts above given the rational formula must be $\begin{array}{l} Fe\left\{\begin{array}{l} NO_2 \\ SNH_2 \end{array}\right. \\ \parallel \\ Fe\left\{\begin{array}{l} SNH_2 \\ NO_2 \end{array}\right. \end{array}$. Similar compounds with nickel, cobalt or manganese have not yet been obtained.—*Ber. Berl. Chem. Ges.*, xii, 461, March, 1879.

G. F. B.

6. *On a New Method of producing Ketones.*—Von Bechi has modified the method for preparing ketones originally suggested by Freund. In place of using zinc radicals, he employs iodides of the alcohol radicals in presence of sodium. In a dilute etherial solution of equal molecules of ethyl iodide and benzoyl chloride, well cooled, is placed the necessary quantity of sodium; at first no action is observable, but soon a yellow powder separates consisting of sodium iodide and chloride. After 48 hours, the whole is extracted with ether and the ether evaporated. A brown liquid is left, which washed with water and fractionated, distills between 205° and 210°, is a light yellow refractive oil of agreeable odor having the composition of phenylethylketone. The reaction is as follows:

$$\left\{\begin{array}{l} C_6H_5 \\ COCl \end{array}\right. + \left\{\begin{array}{l} C_2H_5 \\ I \end{array}\right. + Na_2 = NaI + NaCl + CO\left\{\begin{array}{l} C_6H_5 \\ C_2H_5 \end{array}\right..$$

The method appears general.—*Ber. Berl. Chem. Ges.*, xii, 463, March, 1879.

G. F. B.

7. *On the Production of Aurin.*—Clermont and Frommel have succeeded in producing aurin directly by acting upon phenol by a mixture of carbonous oxide and oxygen in sealed tubes.

$$(C_6H_5OH)_3 + CO_2 = \left.\begin{array}{l} C_6H_4OH \\ C_6H_4OH \end{array}\right\} C \left\{\begin{array}{l} C_6H_4 \\ O \end{array}\right\}.$$

The CO_2 must be nascent to produce the effect.—*C. R.*, lxxxviii, 655, March, 1879.

G. F. B.

8. *Radiometer.*—In recent numbers of *Nature* (April 3rd and April 10th, 1879), Mr. W. CROOKES gives an abstract of his later researches on the "Repulsion resulting from Radiation." He first discusses the amount of repulsion produced by radiation on disks of various kinds and coated with different substances. The very delicate and ingenious apparatus, by which the repulsive forces were compared, is described at length; and the description shows what great skill has been acquired in controlling the obscure phenomena, which Mr. Crookes has so successfully elucidated. For details and numerical results we must refer to the original papers. The repulsions were measured both when no screen was interposed, and also when a cell of water was inserted in the path of the rays; and the difference in the relative effects under these conditions is very striking. These phenomena, which are similar to those first described by Melloni under the name of "Thermocrosis" are among the most interesting results of the investigation. In order to compare the two classes of results, it was first determined that the actual amount of repulsion on a lamp-blacked disk, when the water-screen was interposed, was only one-twelfth of that exerted by the standard candle flame when no screen was in the way, the distance of the candle and other things being of course equal. With the effect on the standard lamp-blacked disk the other repulsions were compared and hence if the direct effect of the source employed on this disk is arbitrarily expressed by the number 100, the effect of the same source on the same disk through the given water screen but under otherwise identical conditions, would be, according to the determination just referred to, expressed by the number 8·3. The other numbers of the following table have a similar meaning.

	No screen.	Water screen interposed.	Per cents with water screen.
Lampblack (standard disk),	100·	8·3	100·
Chromic oxide (pale green),	71·5	1·7	20·4
Copper tungstate,	51·2	6·4	76·8
Prosulphocyanogen,	43·9	1·0	12·0
Saffranin,	41·0	4·3	51·6
Hydrated zinc oxide,	40·5	1·2	14·4
Barium sulphate,	37·4	0·3	3·6
Selenium precipitated,	35·8	5·8	69·6
Copper oxalate,	30·1	3·3	39 6
Calcium carbonate,	28·5	0·3	3·6

It appears from this table that the substances experimented on may be divided into two classes.

(1.) Negative: those in which the repulsion behind water bears a *greater* proportion to the standard than when no screen is interposed.

(2.) Positive: those in which the repulsion behind water bears a *less* proportion to the standard, than when no screen is interposed.

Amongst Class 1, are copper tungstate, saffranin, selenium and copper oxalate. Amongst Class 2, chromic oxide, persulphocyanogen, hydrated zinc oxide, barium sulphate and calcium carbonate. Evidently these differences must correspond to a difference in the capacity of absorbing the luminous and the non-luminous ultra red rays, or in other words to the thermocrosis of the several pigments employed.

As might be expected, the differences of qualities just described are brought out most strikingly when coatings of opposite classes are balanced against each other on the vanes of the movable fly of a radiometer, and this instrument can be constructed with a movable glass cap made tight by cement, so that the fly may be removed and the vanes shifted at pleasure. We quote from Mr. Crookes's paper the following description of the singular results he thus obtained.

"Disks coated on alternate sides with chromic oxide and precipitated selenium move in one direction to the naked flame of a candle and in the other direction when a water screen is interposed. With saffranin and hydrated zinc oxide, the instrument does not move at all when exposed to the naked flame, but revolves when a water screen is interposed. With thallic oxide and Magnus's green platinum salt, the instrument moves strongly when no screen is interposed, but is stopped with a water-screen. These results are all in conformity with the figures."

"A pith radiometer coated with precipitated selenium and chromic oxide was exposed to the radiation from a colorless gas flame of a Bunsen burner, and also to the same colored intensely green by thallium. To the eye, by this light, the chromic oxide looked nearly white and the selenium black. The rotation due to the repulsion of the chromic oxide was however apparently as strong as when the non-luminous flame was used. This experiment proves that certain substances have an opposite absorptive action on rays of dark heat to what they have on light, and that an optically white body may be thermically black, and vice versa. In this case, for instance, chromic oxide was optically green and thermically black, while scarlet selenium was thermically white and optically black."

It was originally thought that a slice of tourmaline, being black to a ray of light polarized in one plane and white to a ray polarized in the other plane, would be repelled when the incident light was quenched by it, and not affected when the incident light passed through it. Mr. Crookes's measurements, however, show that this action does not exist to any appreciable degree. He experimented on a plate of tourmaline suspended in vacuo on a torsion balance, and measured the amount of repulsion produced by a beam of polarized light when in different planes, and he explains the negative results by saying that while the repulsion resulting from radiation is almost entirely a surface action, the action of a tourmaline on a polarizer is one in which thickness is necessary.

The analysis which Mr. Crookes next gives of the effect of the shape of the vanes of a radiometer in influencing the amount and direction of repulsion is very ingenious, and highly interesting; but the discussion cannot be made intelligible without the numerous figures with which the papers are illustrated. It is sufficient to say that the effects are shown to be in accordance with the theory which Mr. Crookes has so fully worked out. One of the most remarkable of these effects is that produced by the viscosity of air which at a rarefaction of 129 millionths of an atmosphere, appears to be only a little less than its viscosity at the normal density, and hence the vanes of a radiometer at a speed of 100 revolutions a minute exert a considerable drag on a disk of mica rotating just above them.

In reading these very interesting papers one is greatly impressed by the perfection to which the mercury pump, and the means of measuring the degree of exhaustion which the pump produces, has been brought. In some of his experiments Mr. Crookes speaks of carrying the exhaustion to four ten-millionths of an atmosphere, and we quote as follows from the close of his article.

"In concluding this abstract of my researches on Repulsion resulting from Radiation I cannot refrain from pointing out how erroneous the ordinary ideas of a 'vacuum' are. Formerly an air pump which would diminish the volume of air in the receiver one thousand times was said to produce a vacuum. Later a 'perfect vacuum' was said to be produced by chemical absorption, and by the Sprengel pump, the test being that electricity would not pass; this point being reached when the air is rarefied one hundred thousand times. Now Mr. Johnston Stony has calculated that the number of molecules in a cubic centimeter of air at the ordinary pressure is probably something like one thousand trillions. When this number is divided by 2,500,000 there are still four hundred billion molecules in every cubic centimeter of gas at the highest exhaustion to which I carried the experiment, a rarefaction which would correspond to the density of the atmosphere about seventy-five miles above the earth's surface, that is, if its density decreases in geometrical progression as its height increases in arithmetical progression. Four hundred billion molecules in a cubic centimeter appear a sufficiently large number to justify the supposition that when set into vibration by a white hot wire they may be capable of exerting an enormous mechanical effect."

9. *The Magic Mirrors of Japan.*—The bronze mirrors of Japan are usually circular, from three to twelve inches in diameter, made of bronze, and with a bronze handle covered with bamboo. The reflecting face is generally more or less convex, polished with a mercury amalgam and the back is ornamented with a varied design. The magic property, which is only possessed by a few rare specimens, appears when a bright beam of light is reflected by the polished surface on to a screen. There is then seen on the screen an image formed of bright lines on a dark ground more or less perfectly representing the pattern on the back of the mirror, although not only is the latter wholly hidden from the light but also the polished surface itself, if looked at directly, acts like an ordinary mirror reflecting the objects in front of it, and giving no indications whatever of the raised patterns on the back. In the "Friday evening discourse at the Royal Institution" of Jan. 24, reported in *Nature* of April 10th, Prof. W. E. Ayrton gives a full

and satisfactory explanation of this remarkable effect, which so far from being intentional on the part of the manufacturers of the mirrors, appears to have been quite unknown to the Japanese, although known to the Chinese from the earliest times. It appeared from the experiments of Professor Ayrton that: 1, when a divergent beam of light fell on the mirror the pattern appeared as bright on a dark ground; 2, when the beam was parallel the pattern was invisible; 3, when the beam was convergent the pattern appeared as dark on a light ground. These and similar experiments exhibited by the lecturer all point to the conclusion that the effect is caused by inequalities in the curvature of the reflecting surface corresponding to the raised pattern on the back, the portions where the relief increases the thickness of the plate being flatter than the remaining convex surface, and even being sometimes actually concave. Professor Ayrton fully describes how such an irregular form would result from the peculiar mode by which the Japanese produce the polished surfaces; whenever the bronze casting is thus worked sufficiently thin to determine a "buckling" of the metal. This result is very exceptional. No thick mirror reflects the pattern on the back, and not more than two or three per cent of the ordinary Japanese bronze mirrors show the magic property clearly. J. P. C., JR.

II. GEOLOGY AND MINERALOGY.

1. *The Cincinnati Group.*—A committee was recently appointed by the Cincinnati Society of Natural History to consider "questions of geological nomenclature," and especially the propriety of using the term "Cincinnati Group," as first proposed by Meek, for the Hudson River Group, and the age of the Lower Silurian rocks of Southwestern Ohio, Southeastern Indiana and Kentucky. The following are extracts from this very satisfactory report.

"The fossils found in the strata, for twenty feet or more above low water mark of the Ohio river, in the first ward of the city of Cincinnati, and on Crawfish creek, in the eastern part of the city, and in Taylor's creek, east of Newport, Kentucky, at an elevation of more than fifty feet above low water mark in the Ohio river, indicate the age of the Utica Slate Group of New York. A fauna is represented in these rocks that is not found above or below them. Within this range we find the *Triarthus Beckii*, *Leperditia Byrnesi*, *Leptobolus lepis*, *Buthotrephis ramulosa*, and several species of Graptolites, Crinoids, Bryozoans and Brachiopods, that seem to be confined within its limits. * * *

"Above the range of the *Triarthus Beckii*, the fossils, as well as the position of the rocks, indicate the age of the Hudson River Group of New York, and we have no hesitation in so referring them, and entertain no doubt of the correctness of the reference.

* * *

"In Southeastern Indiana neither the Trenton nor Utica slate appear, and, consequently, we refer all the Lower Silurian rocks of that State to the Hudson River Group.

"The Trenton Group is not exposed at Cincinnati, nor at any point in Ohio west of the city, but we think it is probable that it may be represented in the banks of the Ohio river a few miles east of the city. The Utica Slate is represented in Ohio only in the banks of the river, at the city of Cincinnati, and east of the city, and in the excavations near the mouths of the streams which enter the river east of the city. Consequently all the Lower Silurian rocks in Southwestern Ohio belong to the Hudson River Group, except those represented by the small exposures in the banks of the river at Cincinnati, and east of the city, in the immediate vicinity of the river.

"The conclusion to which we have come is, that all the Lower Silurian rocks which we have had under consideration, are to be referred to the Trenton, Utica Slate and Hudson River Groups, and that the name 'Cincinnati Group' should be dropped, not only because it is a synonym, but because its retention can subserve no useful purpose in the science, and because it will, in the future, as in the past, lead to erroneous views and fruitless discussion. And we would add that so far as any investigations of these rocks have been made, they have not led to any other or further subdivisions than those which we have adopted, and which have been so thoroughly and firmly established by the geologists of the State of New York."—Signed: S. A. Miller, Fred Braun, Jno. Mickleborough, John W. Hall, Jr., E. O. Ulrich, A. G. Wetherby, Geo. W. Harper, Paul Mohr, C. B. Dyer, R. M. Byrnes.

This Report, besides appearing in the publications of the Cincinnati Society, is also published in the tenth Annual Report of the Geological Survey of Indiana, where it is followed by a long list of the fossils found over the region referred to, in the Hudson River, Utica Slate and Trenton Groups, by S. A. Miller of Cincinnati.

2. *Atlas to the Coal Flora of Pennsylvania, and of Carboniferous Formations throughout the United States;* by LEO LESQUEREUX. Second Geological Survey of Pennsylvania.—This atlas by Mr. Lesquereux is a volume of eighty-seven plates, issued in advance of the volume of descriptive text. The plates are of remarkable beauty and perfection. The drawings were prepared with great care and the engraving is excellent. To Mr. Lesquereux, the author, and to Professor Lesley and the Geological Commissioners of Pennsylvania, who have had the volume published in such admirable style, the thanks of all friends of paleontological botany, the world over, will be given without stint. The work at once becomes the necessary hand-book for all who would study American coal plants. The atlas contains figures of 260 species which have been named and described by Mr. Lesquereux, and of these 122 are now for the first time figured.

Of his modifications of classification—such as his new genus Pseudopecopteris—we can better judge when the volume of text is received. Over thirty species of *Neuropteris* are figured, and more than twenty of Pecopteris, and the whole department of fossil botany receives new illustrations from American specimens. Much light is thrown upon the Cordaites group, a class of Carboniferous plants hitherto a great puzzle to botanists. We shall notice this rich contribution to science more in detail when we have received the volume of descriptions.

3. *Materialien zur Mineralogie Russland, von Nikolai von Kokscharow.* Vol. viii, pp. 177–384, vol. ix, pp. 1–32.—Mineralogists will welcome an addition to the great work of Professor Kokscharof on the Mineralogy of Russia; the seventh volume is thus completed and an eighth commenced. The description of the crystalline form of each species considered is marked by the same accuracy and thoroughness that has characterized the work from the beginning. The following are the more important species described: Breunerite; pyrite; species of the mica group; waluewite (a new species near xanthophyllite); perofskite; eudialyte.

4. *Neues Jahrbuch für Mineralogie, Geologie and Paleontologie.*—The long known and highly valued Jahrbuch für Mineralogie, etc., has passed into the hands of a new corps of editors: Professor E. W. Benecke, in Strassburg, will have charge of the Geology and Paleontology; Prof. C. Klein, in Göttingen, of the Mineralogy; and Prof. H. Rosenbusch, in Heidelberg, of the Lithology. The first number under these editors has just appeared, (drittes u. viertes Heft, 1879). It contains a large number of original articles, and with the correspondence and extracts of papers in the different departments, covers 255 pages. The many workers in science who have used the Jahrbuch in years past, will wish for it a long-continued career of usefulness.

5. *Brief notices of some recently described Minerals:—Huntilite.* Described by Prof. Henry Wurtz, as occurring in two varieties. The most abundant variety is amorphous, often porous and crumbly, dark slate-gray, or almost black in color, and entirely dull in luster. The other kind has a lighter slate-color, a crystalline structure, and probably one cleavage; it is intimately associated with calcite. The hardness is 2·5; the streak is bronze-color; the mineral is sub-malleable. Analyses of the two kinds gave the following results:

1. Amorphous. 2. Crystallized.

	As	Sb	S	Hg	Ag	Co	Ni	Fe	Zn	H_2O	gangue.		
1.	21·10	3·33	0·78	1·04	59·00	3·92	1·96	3·06	2·42	0·19	3·23	=100·03	G.=7·47
2.	23·99	4·25	1·81	1·11	44·67	7·33	2·11	8·53	3·05	0·33	1·65	= 98·83	G.=6·27

The mercury is believed to be present as amalgam; the sulphur as pyrite; after the deduction of these, the following ratios are obtained, the arsenic and antimony being taken together, and all the metals combined, according to their quantivalences:—As : $\overset{I}{R}$ = 1:2·90 (amorphous) and = 1:2·99 (crystalline). The general formula $AsAg_3$ is proposed, but the results of the analyses would suggest grave doubts as to the homogeneity of the material examined. Found at the Silver Islet Mine, Lake Superior. Named after Dr. T. Sterry Hunt.—*Engineer. and Mining J.*, Jan. 25, 1879.

Animikite. Announced provisionally by Prof. Wurtz. It occurs sometimes in incrustations over masses of huntilite; also in large isolated plates or slabs. Specific gravity =9·45. Color white or grayish-white. Fracture fine granular, conchoidal. An analysis gives: Sb 11·18, As ·35, S 1·49, Hg ·99, Ag 77·58, Co 2·10, Ni 1·90, Fe 1·68, Zn 0·30, gangue 1·68=99·31. Found at the Silver Islet Mine, Lake Superior. Named from the Indian word *animikie*, meaning *thunder*, whence Thunder-Bay.—*Ibid.*, Feb. 22.

Randite. Occurs as a lemon-yellow incrustation on granite from Philadelphia. Earthy, probably crystalline. Hardness =2·3. An analysis upon ·047 gr. gave:—CaO 32·50, U_2O_3 31·63, H_2O 6·53, (CO_2 29·34 by difference) =100. The formula deduced is $Ca_4U_2C_6O_{20}+3H_2O$, which, in case it is confirmed by further examination, would place it near liebigite. Named after Mr. Theodore D. Rand, of Philadelphia.—*Proc. Acad. Nat. Sci. Philadelphia*, 1878, 408.

Hannayite, Newberyite. Two new phosphates from the guano of the Skipton Caves, Victoria, described by vom Rath. Hannayite crystallizes in the triclinic system; cleavage basal perfect, less perfect parallel to the two prismatic planes. Specific gravity =1·893. The mean of two analyses gave: P_2O_5 45·70, MgO 18·90, Ammonia 8·09, H_2O 28·20=100·89. The loss of water between 100° and 120° is 21·08 per cent.

Newberyite crystallizes in the orthorhombic system. The cleavage is brachdiagonal perfect, also basal imperfect. An analysis gave: P_2O_5 41·25, (MgO 23·02 by difference), H_2O 35·73=100·00. The formula deduced is $Mg_2P_2O_7+7aq$.—*Bull. Soc. Min. France*, 1879, 79.

III. BOTANY AND ZOOLOGY.

1. *Catalogue of the Davenport Herbarium of North American Ferns, Massachusetts Horticultural Society*; by GEORGE E. DAVENPORT. Salem, 1879. 8vo, pp. v, 42.—This is a very full catalogue of the known Ferns of the United States and British America, and contains the names of collectors and donors, and the localities of all the North American ferns in the very rich collection which Mr. Davenport has presented to the Massachusetts Horticultural Society. The genera and species are arranged very nearly in the same order as that of Mr. Robinson's check-list, and that is based on the system of Mettenius. The Catalogue contains the names of 32 genera and 142 species, all but one or two of which are represented in the Herbarium by North American specimens. A good many excellent notes on critical forms are scattered through the book, and no student of our Ferns can afford to neglect its pages. *Pteris serrulata* appears here for the first time as a North American species, having been discovered growing spontaneously in the vicinity of Mobile, Alabama, by Mr. Charles Mohr of that city. *Polypodium pectinatum* and *Adiantum tenerum* are also for the first time announced as Ferns

of the United States. Specimens of the former, the name of which had not been definitely settled, had been sent to Mr. Chas. E. Faxon to draw for the *Ferns of North America*, and that gentleman noticed the difference between them and his own specimens of *P. Plumula*. He brought the matter to the attention of the writer of this notice, who then decided to call the large form *P. pectinatum* Linn., and the smaller one *P. Plumula*. The *Adiantum* had been for a year or more in the hands of Mr. Davenport and Mr. Faxon, as unchallenged *A. Capillus-Veneris*, and was first pronounced something different from that species by Mrs. Dr. Barnes, of Syracuse, who obtained fronds from living plants brought from Ocala, Florida, by Mr. Christian Beh, in March, 1877.

Mr. Davenport retains *Pellæa brachyptera*, of Baker, as a distinct species, and is no doubt right in doing so. Within the last few years it has been sent in by many collectors, and keeps its distinctive characters even better than some other recognized Californian Ferns. *Aspidium Bootii* of Tuckerman, is maintained as a distinct species, and so is *A. Americanum*, of Davenport, the *A. spinulosum* var. *intermedium* of Gray's manual.

An appendix gives a list of doubtful and excluded species, and one introduced species, *Adiantum cuneatum*, which was found "Established at Valley Falls, Rhode Island" by Mr. J. L. Bennett, who will doubtless give full particulars of his discovery in his forthcoming "*Plants of Rhode Island.*" [It seems hardly worth while to introduce into a work like this a mere escape from cultivation, doubtless transient.] The Catalogue is beautifully printed, and contains very few typographical or other errors to mar its excellence. D. C. E.

2. *Cane-sugar in Early Amber Cane.*—Professor GOESSMANN (Fifteenth Annual Report of Mass. Agricul. College) comes to the following conclusions respecting the proportions of cane and grape-sugar in this variety of Sorghum at different periods of its growth: 1st. Grape-sugar appears in the cane at an early stage of its growth, and increases slowly to from three to four per cent before cane-sugar is formed; 2d. Cane-sugar is first noticeable at the time when the flower stalks become visible above the leaves, and its amount increases steadily until the seeds are of full size, yet still soft; 3d. The relative proportion of grape-sugar to cane-sugar at any time before the hardening of the seeds, do not exceed 3·16 per cent of the former to 8·49 per cent of the latter, in the majority of cases it was about three to seven. G. L. G.

3. *Number of the digestive glands in Dionæa.*—Léo Errera, thinking it would be physiologically interesting to know the number of glands to each flytrap of *Dionæa*, made a careful examination in this regard. He found an average of sixty to each square millimeter, or about 8,000 to each leaf. See Comptes-Rendus des Sèances de la Soc. Roy. Bot. de Belgique, April, 1879, p. 56.

A. G.

4. *Characeæ Americanæ, Illustrated and Described by* TIMOTHY F. ALLEN, A.M., M.D., etc.—This work is published by

the author himself, in very handsome style, each part consisting of one leaf or page of letter-press and a plate, in quarto form. The plate is printed in green color. The second fascicle has also a wood-cut in the letter-press. It is evident that Dr. Allen is making this a labor of love, regardless of expense. He announces that his work "will be issued each month, and will include every species and variety known to American waters. The author will be happy to send the work to botanists and receive in return the *Characeæ* of their collecting, to the number of fifty specimens of each variety." Directions for collecting and preparing specimens of *Charæ* are appended to the announcement on the cover. Each plate gives a view of a specimen in the natural size, a fructiferous portion magnified, and a cross-section of stem. The general view of the plant is particularly good. The magnified portions have a certain stiffness and solidity, which will probably be got rid of in future trials. Dr. Allen should be, and we may be sure will be, encouraged to carry on to completion an undertaking which will make an obscure and neglected branch of botany popular in this country, and which may incite to new discoveries. A. G.

5. *Malesia; Raccolta di Osservazionie Botaniche interno alle Piante Dell' Archipelago Indo-Malese e Papuano, da* ODARDO BECCARI. Vol. I, fasc. 1–3. 1877–78. 256 pp. tab. I–XV, 4to. Geneva.—Dr. Beccari, the successful explorer of New Guinea, Borneo, etc., and now the Director of the Royal Museum at Florence, is publishing in this fine work his botanical discoveries and those of Signor D'Albertis as fast and as far as he is able to elaborate them. Thus far the articles are all by his own hand; and the work bids fair to be one of the most important of recent contributions to systematic botany. It is not often that we can have such an interesting accession to Phænogamous Botany as is Beccari's *Corsia ornata*, a small root-parasitic plant of New Guinea (dedicated to the Marquis Corsi Salviati), which may be speculatively viewed as a sort of survival, representing a type from which *Orchideæ* and *Burmaniaceæ* have proceeded. The 6-phyllous perianth has five similar and lorate divisions, and a sixth much larger and dilated one which bears a nectary within; but this is the posterior one of the outer series. The andrœcium has its full compliment of six wholly normal and similar antheriferous stamens, with the inner series of these the three carpels of of the ovary normally alternate; and the large placentæ are carried inward on imperfect dissepiments, thence their lamellæ are revolute toward the back of the cells.

The first fascicle is devoted to Palms; the second to these and to *Icacineæ*, *Menispermaceæ*, *Monimiaceæ*, etc.; with new genera in all; the third has an excursus on *Nepenthes* and its distribution, and describes new *Burmanniaceæ*. A. G.

6. *On the Self-fertilization of Plants;* by the Rev. GEORGE HENSLOW, M.A., F.L.S., etc. A memoir in the Transactions of the Linnean Society of London, ser. 2, Bot. vol. i. pp. 318–398, with a plate. Read Nov. 1, 1877. Issued 1879.—This paper is

elaborate, mostly able as well as ingenious, in all respects considerable, and unconvincing. Its thesis is, the Darwinian "Nature abhors perpetual self-fertilization," read backward. It concludes that, "not only are the majority of plants self-fertilizing, but that those which are exclusively so propagate abundantly and with extraordinary rapidity, are best able to establish themselves in foreign countries, as, being quite independent of insects, they run no risk of extermination on that score; . . . that, so far from there being any necessarily injurious or evil effects resulting from the self-fertilization of plants in a state of nature, they have proved themselves to be in every way the best fitted to survive in the great struggle for life." The hypothesis is also advanced "that they are all degraded forms," and that *therefore* "their ancestral life-history is a longer one than that of their more conspicuous and intercrossing relations." We fail to see how this follows, except upon the assumption that the earliest phænogamous plants had the most highly organized blossoms; and that would not accord with vegetable paleontology.

Mr. Henslow rejoices that he has one staunch supporter; "for, as has been seen, Mr. T. Meehan has arrived at the same conclusion;" and indeed he builds not a little upon facts supplied by Mr. Meehan's observations. He cites the latter's "admirable paper, which was reproduced in the 'Gardner's Chronicle' for Sept. 11, 1875, and is in fact an 'apology' for self-fertilization." As he then marshalls twenty reasons for believing particular plants to be normally self-fertilizing, and nineteen "chief facts which may be regarded as occurring correlatively with self-fertilization, some being actual causes which directly or indirectly bring it about," it would appear that it is no longer self-fertilization, but rather the existence and *raison d'être* of cross-fertilization that stands in need of apology, or of explanation.

He freely concedes that the flowers of many plants, and some whole orders, are so constructed that intercrossing is for them a necessity; also that most of those which are believed "to be normally self-fertilizing" because they can and do fertilize themselves habitually," yet "may in some cases be cross-fertilized by insects." It is admitted that the structure of the latter is *adapted*—most variously and wondrously adapted—to being fertilized by particular insects. As this comes to pass in plants and flowers of the highest organization and greatest specialization, Darwin and his school conclude that this is a most advantageous outcome, and means some real good to the species; that when this is accompanied with a loss of self-fertility, it is the loss of something no longer useful, something better than self-fertility having taken its place. But Mr. Henslow, reading this the other way, having determined "that self-fertilization is *per se* a decided advantage," and free from injurious liability, comes to regard intercrossing as merely "a compensatory process for the loss of self-fertility."

But how and why did this "compensatory process come to pass? It is conceived on both sides that flowers were "primordially inconspicuous." (To this Henslow adds hermaphrodite and self-fertile, but that need not here come into account.) Both agree that insects have mainly determined their conspicuousness. Darwin says this has been determined through natural selection by the survival of the more and more conspicuous variations, correlated with their producing something good for the insect of which the coloration was a sign, and that the preferential survival of the more showy and attractive was a consequence of some benefit of the intercrossing. Henslow propounds the view that insects have determined the conspicuousness more directly, and not by benefiting but by irritating the flowers. "These, by being greatly stimulated by the repeated visits of insects, tend to become hypertrophied. Hence the corolla enlarges, becomes more brightly colored, the nectariferous organs increase the quantity of secretion, and the stamens develope more pollen. Such being the case, nourishment is withheld from the pistil, which is delayed in its development; consequently such a flower is very generally proterandrous." Mr. Darwin might accept this as an ingenious conception of the way the specialization comes about, still insisting on the advantage of the resulting intercrossing—" or else the thing would hardly come to pass," as the poet has it. And Mr. Henslow's hypothesis has to be supplemented to account for proterogyny, which is not much less common. But Henslow's supposed process works evil instead of good, and is therefore utterly anti-Darwinian and "dysteleological." For the result is a disturbance of the equilibrium and proper correlation between the andrœcium and gynœcium; and this, carried further, should upon this view result in the monœcious and diœcious states. So, accordingly, the cross-fertilization which comes into play in the case of separated sexes, and in that of self-sterile hermaphroditism, is not for any good there is in it *per se*, but because it may no better be. And all the elaborate, exquisite, and wonderfully various modes of adaptation of flowers to insects are only ways of repairing the damages inflicted upon blossoms by insects through their persistent visits! Did Mr. Henslow ever ask himself the question why the sexes are separate in animals?

The conclusion which Mr. Darwin had helped us to reach is, that intercrossing should be regarded as the aim in nature and on the whole most beneficial, and self-fertilization as a safe-guard against the risks of crossing; that most hermaphrodite flowers have the advantage of both, the latter for immediate sureness, the former for ultimate benefit. Upon the new view, self-fertilization is the aim and the consummation, and cross-fertilization at best a succedaneum. By it insects may repair the damage they have caused to blossoms through endowing them with "the fatal gift of beauty," and stimulating their organs of secretion; and by it the winds may bring chance relief to those which, at length abandoned by their spoilers, have lost this attractiveness and fallen to the degradation of unisexuality. For these last, as has already been stated, are hypothetically regarded as degraded from higher floral types.

We are bound to glance at some of the considerations which are adduced in support of this thesis. They are multifarious and of unequal value. As has occurred in other cases, so here also, the weightiest objections to Mr. Darwin's view are those which he has himself brought out, namely, the fact that, as tested experimentally under cultivation, while some plants are much increased in vigor and fertility by artificial intercrossing, others are not sensibly benefited; and that the benefit derived in marked cases is not cumulative, but reaches its maximum in two or three generations. And even close breeding under cultivation occasionally gives rise to very vigorous and fully prolific self-fertile races. Then many plants are fully self-fertile in nature, and it is not proved that any such have lost or are in the way of losing either fertility or vigor through continued inter-breeding. But, before drawing from this the conclusion that cross-fertilization is of little or no account in nature, it should be remembered that bud-propagated races are in similar case. Races exist which have been propagated only from buds for hundreds of years, with seemingly undiminished vigor, and there is no proof that any one has succumbed under the process. But for all that we do not doubt that sexual reproduction contributes something to the well-being of the species, besides facilitating its dispersion. Again, no one questions the necessity of fertilization by pollen to the production of embryo in the seed; yet, even in this, the necessity is not so imminent but that some embryos may originate without it. (See preceding volume of this Journal, p. 334.)

In short, the facts brought out by Darwin and others, and all the considerations of the present essay, are best harmonized by the conception which the former has consistently maintained, namely, that an occasional cross suffices to secure the benefit of intercrossing, whatever that may be. Nothing yet appears which seriously disturbs our conviction that just this is what nature generally provides for.

Mr. Henslow's proposition, "The majority of flowers are self-fertile," is doubtless true in the sense that they are capable of self-fertilization, and is not improbable in the sense that they "can and do fertilize themselves habitually." But his inference that the majority of flowers, or that any flowers, actually propagate for a series of generations by self-fecundation, or that a cross if it occur is "exceptional," and of no account, is surely unwarranted by the evidence which he has adduced.

Occasionally the reported facts will not bear scrutiny. *Gentiana Andrewsii*, it is said, never opens at all in America. It opens in sunshine in the middle of the day here in New England. And while looking at closed flowers we have seen a humble bee emerge from one. We have, in this Journal, shown how it is that self-fertilization is impossible during the first three or four days of anthesis, but neatly practicable afterwards. It is rash to infer (as on p. 330) that papilionaceous flowers which shed their pollen early in proximity to the stigma are therefore self-fertilized. In most of the cases adduced the pollen is not lodged upon the stigma, but upon the style below it, and the adaptations for intercrossing, though the mechanism be different, are as explicit as in the analogous case of Campanula. "Fremont pathetically describes the solitary bee that rested on his shoulder at the top of Pike's Peak." The pathos is wasted as respects all but this particular bee; for the entomologists find the alpine region of the Rocky Mountains to be as well stocked with flying insects as are alpine regions in other parts of the world. They do not superabound, but if from the alpine flora we subtract the evidently entomophilous and the anemophilous blossoms, the remainder will be nearly nil. And as to the correlation of this comparative scarcity of insects with the marked conspicuousness of blossoms, this is the way the lesson is read by a most eminent physiologist: "Even the glowing hue of alpine flowers is accounted for by the attraction which brighter-colored individuals exercise upon the insects, scarce in those heights and necessary for fertilization."

One or two of the author's own observations are perhaps to be revised. "*Gaura parviflora* . . . has no corolla and is cleistogamous, in that it is self-fertilizing in bud, as I found in specimens growing at Kew." Were they not imperfectly developed blossoms, perhaps late in the season? Here the flowers open freely and have rose-colored petals. If he will examine fresh specimens of *Scrophularia*, it will soon be clear that his idea of their self-fertilization (p. 371) is a mistake. It is a mere slip in the Genera Plantarum through which abortive stamens are attributed to the cleistgamous flowers of *Epiphegus*. The authors evidently meant to describe the case just as Mr. Henslow found it to be, but used a wrong word.

"Weeds are probably all self-fertilizing or anemophilous. A weed is simply an unattractive plant, and possessing no feature worthy of cultivation." It may be as difficult to define "a weed" as to define "dirt." But, turning to the Handbook of the British Flora, we find, as we expected, that the showy Corn Poppy, Cockle, and Larkspur are denominated weeds. Why weeds should possess the vigor and gain the predominance which they do is a large question, to which other solutions have been offered than that the one which is in this essay very plausibly maintained. We cannot take up the topic here; but, without acceding to his general proposition, we are much disposed to agree with the author in this essay, as respects some of them, that aptitude for self-fertilization may have given them the advantage which has determined their wide dispersion.

The insistence upon the importance of self-fertilization is what gives this essay its value. As a whole it fortifies the proposition, well laid down by Herman Mueller, which Mr. Henslow cites:—"that, under certain conditions, the facility for self-fertilization is most advantageous to a plant, while, under other conditions, the inevitableness of cross-fertilization by the visits of insects is the more advantageous." But this is not our author's thesis. It comes to this: the plan of nature is either cross-fertilization supplemented by close-fertilization, or close-fertilization tempered by cross-fertilization. As restricted to plants the difference is not wide. Regarded generally, the Darwinian axiom is still best sustained. A. G.

7. *On the causes of the change in form of Etiolated Plants;* by Professor GODLEWSKI, Dublany (Poland). Bot. Zeit. 6, 1879. —In 1873, Professor Godlewski published in Flora an account of his investigations respecting the formation of starch in chlorophyl grains. In that memoir he stated that the changes in form which plants undergo in darkness are not due to the suspension of the assimilative process. In 1875 and 1877 he published in the Polish language two short notices of his further observations upon this subject, and which he now fully recounts in the present paper. Only the first series of his later experiments will be referred to now, namely, those bearing upon the question as to the relation of the assimilative process to the change of form in growing plants deprived of light. It is a general rule, to which there are some exceptions, that internodes grown in the dark are longer, and leaves are smaller than those which develope in sunlight. In Pringsheim's Jahrbücher f. wiss. Botanik, vol. vii, p. 213, Dr. G. Kraus has sought to explain the latter fact by the hypothesis that it is chiefly out of assimilated matter freshly formed in growing green leaves themselves that they expand to their full size, and hence the diminutive size of etiolated leaves is thought by him to be directly dependent upon the absence of the assimilative process.

In Professor Godlewski's experiments germinating plants were cultivated in an atmosphere deprived of its carbonic acid, some of them in light, others in perfect darkness, but under similar conditions of temperature and moisture. It was found that when the plantlets had exhausted the food stored in the seed, and had ceased to grow, the total weight of dry organic matter was the same in the green and in the etiolated plants. The plantlets which had grown in the light but in air free from carbonic acid, and where assimilation could not take place, did not bear the slightest resemblance in form to etiolated plants. They were of perfectly normal habit. G. L. G.

IV. ASTRONOMY.

1. *Orbits of the binary systems, μ Herculis and* 298 *Struve;* by W. BEEBE.—The double star μ Herculis had been observed since 1858, and has shown a change of about 180° in the position angle though the observations, twenty-eight in number, and by twelve different observers, exhibit large discrepancies and are not all trustworthy.

The orbit was computed by Herschel's first method and agrees with the interpolation curve quite closely. The corrections to E, T and P., obtained by Klinkerfue's first method did not, however, improve the agreement. The eccentricity is somewhat uncertain and the periodic time probably too large. The observations for 298 of O. Struve's catalogue are thirteen in number and agree tolerably well. It has been observed since 1843, and the position angle up to 1878 had changed about 130°. The orbit was computed by Herschel's second and Klinkerfue's first method. The orbit however is not definitive.

For the observed places used I am indebted to Mr. Burnham, who kindly collected for me all the available material.

	μ Herculis.	298 O Σ.
T	1873·4	1881·7
P	225· years	79·2
Ω	34°	5° 58′
π-Ω	143° 52′	357 17
i	37 10	66 35
e	·731	·585
a	2″·69	1″·23

New Haven, April 5th.

2. *Report of the Observations of the Total Solar Eclipse, July* 29, 1878, *made at Fort Worth, Texas.* Edited by LEONARD WALDO, Assistant at the Observatory of Harvard College. 60 pp. 4to, with 4 plates.—The Fort Worth Eclipse party consisted of Messrs. Waldo, Willson, Rees, Pulsifer and Seagrave, a volunteer party whose special object it was to record such phenomena as might aid in establishing the correct theory regarding the solar corona. Observations were made with the naked eye, the telescope, the spectroscope, the polariscope, and photographs of the corona were taken both with and without double refracting prisms. Professor Pickering and Mr. Waldo consider that the double image photographs imply tangential polarization of the light of the corona.

Mr. Pulsifer observed the reversal of the lines of the spectrum with the bright lines (except C) shortened at each end. He infers therefrom that his slit extended beyond the reversing layer on each side. He hence infers a minimum thickness of the reversing layer of 524 miles. H. A. N.

3. *Catalogue of Stars observed at the United States Naval Observatory, during the years* 1845–1877, *and prepared for publication by* Professor M. YARNALL, U. S. N., by order of Rear Admiral JOHN RODGERS, U. S. N., Superintendent. Second edition, revised and stereotyped, 280 pp. 4to. Washington, 1878.—The author of this Catalogue of Stars, Professor Yarnall, died on the 27th of February, 1879; he lived to correct the last proof sheets of this work, but not to see the volume in its completed form. This catalogue includes all the work done at the Observatory with the old instruments, and thus, as the author remarks, forms an epoch in the history of the Observatory. It is a work of high intrinsic excellence and is of especial interest as containing the results of the life work of a most accurate, patient and untiring observer.

4. *Astronomical and Meteorological Observations made during the year* 1875 *at the United States Naval Observatory*, Rear Admiral C. H. DAVIS, U. S. N., Superintendent. Published by authority of the Hon. Secretary of the Navy. 4to. Washington, 1878.—In addition to the description of observations made at the Observatory in 1875, which cover 560 pages of the volume, it also contains three Appendixes; one of them is entitled Researches on the Motion of the Moon made at the U. S. Naval Observatory, Part I, by Professor Simon Newcomb. The great work undertaken by Professor Newcomb has as its object the re-investigation of the subject of the Moon's motion, with a view to ascertaining the cause of the deviations of the observations from Hansen's Tables. The part of the work now published contains a reduction and discussions of observations of the moon before 1750, involving the use of much material hitherto but little known. The remaining part, not yet completed, will contain a computation of the action of the planets and the deduction of the mathematical theory of the inequalities of long period in the moon's mean motion.

5. *On the Spectrum of Brorsen's Comet;* by W. H. M. CHRISTIE.—With reference to Professor C. A. Young's Note on the Spectrum of Brorsen's Comet, it may be of interest to mention that observations made at the Royal Observatory, Greenwich, confirm his conclusion as to the coincidence of the brightest band in the comet spectrum with the green band of carbon.

We were not able to examine the comet's spectrum till April 17, as the Great Equatoreal was in the workmen's hands till that date for alterations required to allow of the more convenient use of the spectroscope. On that evening, and again on April 19, the comet's spectrum was repeatedly compared by Mr. Maunder and myself, with the spectrum of alcohol taken in a vacuum tube. The less refrangible edge of the brightest comet-band coincided as exactly as could be determined with the corresponding edge of the green carbon-band at 5,200, but the comet-band was very much wider, extending two-thirds of the way toward F (i. e., about 200 tenth-meters), and covering the carbon-band at 5,200 (about 30 tenth-meters broad) and the two following fainter bands at 5,100 and 5,020. The comparisons were made on April 17 by the help of an occulting bar, and on April 19 with Hilger's bright-line micrometer, illuminated by red light. With the latter, readings for the comet- and carbon-bands respectively, agreed within half a tenth-meter. The half prism spectroscope with a dispersion of 10° from A to H (equivalent to two prisms of 60°) was used on the 13-inch equatoreal. From spectroscopic observations of the carbon compound, printed in the volume of Greenwich Observations, 1875, it appears that the bands in the spectrum of alcohol are identical with those in the spectra of olefiant gas, and of carbon monoxide and dioxide.

A second band was seen in the orange of the comet's spectrum approximately coincident with the carbon band about 5,600.

This band was of about one-fourth the brightness of the principal band.

The results on April 17 were obtained without a knowledge of Professor Young's work, and thus afford an independent confirmation of his conclusion.—*Nature*, May 1.

Royal Observatory, Greenwich, April 21.

V. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Notes on Pagosa Springs, Colorado;* by Lieut. C. A. H. McCAULEY, Third Cavalry, Assistant Engineer, U. S. A. 27 pp. 8vo. Report to the Secretary of War, Feb., 1879; printed by order of Congress.—The Pagosa Springs are situated in the valley of the San Juan river, southern Colorado, on the road from Tierra Amarilla, New Mexico, to the Animas region. The springs have been long known and used by the Ute Indians; they received from them their name *Pah-gosa*—from *pah*, water, and *gosa*, boiling. The group of hot springs occupies an area of about twenty-one acres on the western side of the River. Lieut. McCauley describes nineteen of these, and in addition several cold springs forming an independent group; they are situated in an area of the Cretaceous formation. The largest hot spring has a pear-shaped crater sixty-nine feet long and forty-five feet wide, the depth not determined. An apparent ebullition goes on constantly, but it is gaseous and not due to boiling, the waters rising charged with hydrogen sulphide and carbon dioxide. The temperature of this spring was found to be 141° F., that of the river being 40° F., and the highest air-temperature being 49° (December); the temperature at the exits into the river—the outflow is subterranean—was 127° F. The waters contain, besides the gases, chiefly calcium carbonate and sodium sulphate, with smaller quantities of sodium chloride, sodium, magnesium and lithium carbonates, and potassium sulphate. The deposition of solid matter goes on quite rapidly, stalactites and stalagmites, consisting chiefly of calcium carbonate and sodium sulphate, being formed within the pools.

The temperature of the water in the other springs varied mostly between 135° and 140°, though several of them had temperatures, of only 101°–110°. The cold springs are south of the main spring, on the opposite bank of the river and about half a mile distant; their temperature differs but little from that of the air. Lieut. McCauley's Report contains a series of interesting wood-cuts showing the topographical relations of the country about the springs, and also the details in their structure.

2. *Notes by a Naturalist on the Challenger*, being an account of various observations made during the voyage of H. M. S. "Challenger" around the world in the years 1872–1876, by H. N. MOSELY, M.A., F.R.S., Fellow of Exeter College, Oxford, Member of the Scientific Staff of H. M. S. Challenger. 606 pp. 8vo., with a map, two colored plates and numerous woodcuts. London, 1879 (Macmillan & Co.).—These notes make a volume full of facts of interest, popular as well as scientific, relating to the countries and

people visited, icebergs, corals and coral reefs, the habits and nature of some of the stranger animals and plants of the sea and land, and on geological, anthropological and other topics; and they are presented in the direct and lucid style that bespeaks the faithful scientific observer. The author is an able naturalist, and has published many very valuable papers (partly in the Transactions of the Royal Society) as the results of careful work during the cruise and of thorough microscopic investigations since, relating to the structure of *Millepores*, the Alcyonarian relations and structure of *Heliopora cœrulea*, the structure of the *Stylasteridae*, on *Corals*, *Actinaria*, *Planariæ*, and other zoological subjects, besides Botanical notes in the Journal of the Linnæan Society.

3. *Report of the National Academy of Sciences.*—At the meeting of the National Academy of Sciences held in Washington, April 15th to 19th, 1879, the following papers were read:

C. S. PEIRCE.—Ghosts in the diffraction spectra; Comparisons of the meter with wave lengths; On the errors of pendulum experiments, and on the method of swinging pendulums proposed by Mr. Faye; On projections of the sphere which preserve the angles.

HENRY DRAPER.—Confirmations by spectrum photographs of the discovery of oxygen in the sun.

E. C. PICKERING.—On the eclipses of Jupiter's satellites; On two new forms of micrometers.

ALFRED M. MAYER.—On a new form of heliostat.

J. E. HILGARD.—Report on the progress of the international bureau of weights and measures; An account of geodetic acts determined by the Coast Survey in relation to the figure of the earth.

SIMON NEWCOMB.—On the recurrence of solar eclipses.

H. A. NEWTON.—On the influence of Jupiter upon bodies passing near that planet.

S. WEIR MITCHELL.—On the relations of neuralgic pains to storms and the earth's magnetism.

C. F. CHANDLER.—On a new polariscopic method for the detection and estimation of dextro-glucose in the presence of cane sugar and inverted sugars.

H. L. ABBOTT.—On the ignition of high tension fuses.

ELIAS LOOMIS.—The winds on Mount Washington compared with the winds near the level of the sea.

E. W. HILGARD.—The lœss of the Mississippi, and the Æolian hypothesis.

JOSEPH LECONTE.—The extinct volcanoes about Lake Mono and their relation to our glacial drift.

J. S. NEWBERRY.—On the great silver deposits recently discovered in Colorado, Utah, and Nevada.

G. J. BRUSH.—On a mineral locality in Fairfield County, Connecticut.

A. AGASSIZ.—Report on dredgings in the Caribbean Sea by the Coast Survey steamer Blake, Commander John R. Bartlett, United States Navy.

C. V. RILEY.—On the hybernations and migrations of *Aletia argillacea* (the parent of the cotton-worm).

S. H. SCUDDER.—The Palæozoic cockroaches.

E. D. COPE.—On the extinct species of the Rhinoceros and allied forms of North America.

H. MITCHELL.—On the physical hydrography of the Gulf of Maine.

G. K. GILBERT.—On the stability and instability of drainage lines.

A. GRAHAM BELL.—On vowel theories considered in the light of recent experiments with the phonograph and phonautograph.

F. A. P. BARNARD.—Report of the Committee on Weights, Measures, and Coinage.

Professor William B. Rogers was elected President in place of Joseph Henry, deceased. The following new members were elected: Cleveland Abbe, J. W. Gibbs, W. G. Farlow, H. C. Wood.

APPENDIX.

Art. LXIII.—*Polydactyle Horses, Recent and Extinct;* by Professor O. C. Marsh.

It is said that the aborigines of this country, when they first saw the horses brought over by the Spaniards, named the new animal "the beast with one finger nail." Certainly, the single hoof on each foot is the most marked characteristic of the modern horse, and one on which some of his most valuable qualities depend. The nearest living allies of the horse are the ass and the zebra, and they possess the same pedal peculiarities.

In addition to each main digit of the ordinary horse, however, the anatomist finds concealed beneath the skin two slender metapodial "splint bones," which are evidently the remnants of two other toes, originally possessed by the ancestors of the horse. It is an interesting fact that these splint bones are sometimes quite fully developed, and may even support extra digits, which are much smaller and shorter than the main foot. As these small hooflets are usually regarded as a serious detriment to the animal, they are generally removed from the colt soon after birth, but in such cases the enlarged splint bones not unfrequently indicate in the adult their former existence.

Numerous cases of extra digits in the horse have been recorded, and in nearly all of them a single lateral hooflet was present on one of the fore legs. In most instances the occurrence was noted chiefly on account of its rarity, and no record was made of the exact position of the extra hoofs with reference to the main digit, nor of the significance of these useless appendages. Since the attention of the writer was called to the subject, a few years since, he has ascertained that these supernumerary digits are much more common in the horse than has been supposed, and in many cases they appear to indicate a reversion to an early ancestral type.

The figures given below represent, (1) the foot of the modern horse in its normal condition, with the splint bones rudimentary; (2) the foot abnormally developed, with one splint bone bearing a small hooflet; and (3) the foot of an extinct three-toed ancestor of the horse. The feet are all from the left side, and the numbers attached indicate the different digits, counting from the inside. The first and fifth, corresponding to the thumb and little finger of the human hand, are wanting in these figures. A specimen similar to that represented in figure 2 is preserved in the Museum of Yale College.

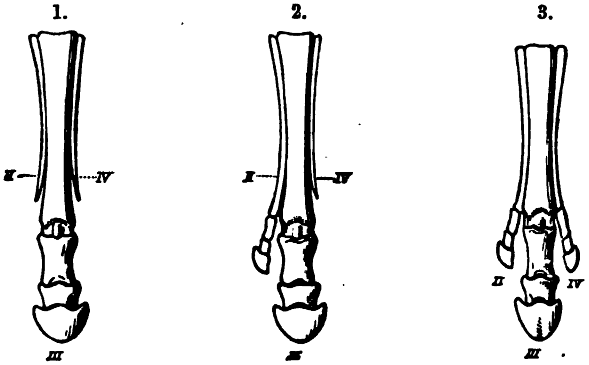

Figure 1.—Fore foot of Horse (*Equus*).
Figure 2.—Fore foot of Horse with extra digit.
Figure 3.—Fore foot of *Hipparion*.

The first recorded instances of extra digits in the horse, known to the writer, are two mentioned by George Simon Winter, in his famous book on Horses, published near the beginning of the last century.[*] One of the horses referred to and figured in this work was "eight-toed," having a small extra digit on the inside of each foot (p. 134, Plate 21 F.). Winter states that this horse was exhibited in Germany in 1663, and a portrait of it preserved in Cologne. His account was derived from a person who had examined the animal. The other horse described by Winter (page 136, Plate 24), had a small hoof on the inside of each fore foot, and this steed, Winter states, he had not only seen but ridden.

Geoffroy Saint-Hilaire has recorded the fact that he examined a fœtal horse which was polydactyle on the fore feet, the left foot bearing three nearly equal digits, and the right but two.[†] Owen has described the right fore foot of a horse with a double hoof, the extra digit being on the inner side, answering to

[*] *De Re Equaria*, Nuremberg, 1703.
[†] *Annales des Sciences Naturelles*, XI, p. 224. Paris, 1827.

the second digit.* Arloing has figured and described similar specimens.† Leidy has described the right fore leg of a horse with a supernumerary digit on the inner side; and Allen subsequently discussed the same specimen.‡ A number of other instances have been recorded, showing that extra digits are by no means rare in the modern horse.

The most interesting case of this kind examined personally by the writer is the horse represented in figure 4. This animal was on exhibition in New Orleans, in the spring of 1878, and Dr. Stanford E. Chaillé of that city first called the attention of the writer to it, and likewise sent a photograph, from which the cut below was made.

4.

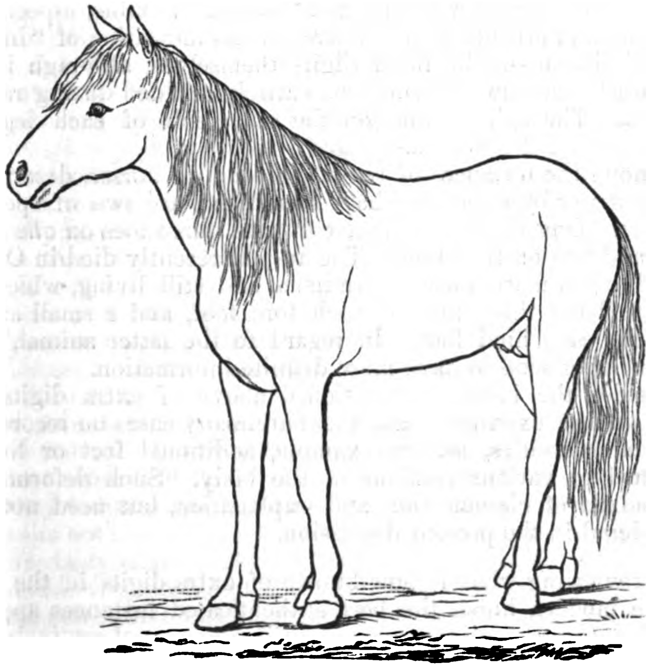

Figure 4.—Outline of horse with extra digit on each foot.

This same horse was subsequently brought to the North, and a few days since was on exhibition in New Haven, Conn., where the writer examined him with some care. The animal is of small size, about ten years old, and is said to have been foaled in Cuba. He is known among showmen as the "Eight-footed Cuban Horse." With the exception of the extra digits, he is well-formed, and doubtless is capable of considerable speed, although some of the exploits claimed for him may fairly be questioned.

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* Osteological Catalogue, Museum Royal College of Surgeons, Vol. II, p. 537. London, 1853.

† *Annales des Sciences Naturelles*, VIII, p. 55. 1867.

‡ Proceedings Academy Natural Sciences, Philadelphia. 1871, p. 112, and 1876, p. 92.

The four main hoofs are of the ordinary form and size. The extra digits are all on the inside, and correspond to the index finger of the human hand. They are less than half the size of the principal toes, and none of them reach the ground. An external examination indicates that the metapodial bone of each extra digit is entire, and at its lower end, at least, is not coössified with the main cannon bone.

There appear to be two phalanges above the coffin bone in each of these digits, which are thus rendered flexible, especially in a fore and aft direction. There was no indication of "interfering" shown on the inner digits themselves, although it is difficult to see how this could be entirely avoided during rapid motion. The splint bone on the outer side of each leg is apparently of the usual shape and size.

Among the instances of recent polydactyle horses, described to the writer by those who have seen them, are two of special interest. One of these was a colt with three toes on one fore foot, and two on the other. The animal recently died in Ohio. Another is a mare, raised in Indiana, and still living, which is said to have three toes on each fore foot, and a small extra digit on each hind foot. In regard to the latter animal, the writer hopes soon to have more definite information.

Besides the instances mentioned above of extra digits in place in the existing horse, there are many cases on record of true monstrosities, as, for example, additional feet or limbs attached to various portions of the body. Such deformities now admit of classification and explanation, but need not be considered in the present discussion.

In reviewing what is now known of extra digits in the feet of the modern horse, the best authenticated instances appear to fall naturally into two groups. The first of these includes digits which are simply cases of reduplication, quite similar to the extra finger occasionally seen in the human hand. Such deformities are apparently a vegetative repetition, the explanation of which has not yet been satisfactorily determined. The second class includes cases where a true digit is formed, the component bones of which are in their normal position, and in proper relation to the rest of the limb. Such instances appear to be clearly due to reversion to some ancestral type. Some digits, which appear at first sight to belong in the first category, may really illustrate the second, but the converse of this is much less likely to be true. The cases of apparent reversion are of especial interest, and it is important to place on record any information in regard to them, so that they may be compared with extinct allies of the horse.

The cases of extra digits in the horse, so far as at present known, show that these appendages make their appearance more frequently on the fore feet than on the hind feet. This is precisely what a study of the fossil forms of equine mammals would lead us to anticipate.

Another noticeable peculiarity of these extra digits, is their more frequent occurrence on the inside of the main digit, while the outer splint remains rudimentary. This, it must be confessed, is directly opposed to the general law of reduction in the ungulate foot, which, briefly stated, is, that of the five original digits, the first or inner one, first disappears; next the fifth, or outer one; then, the second; and last of all the fourth. The third always remains, as in the horse. It would, therefore, be naturally expected, that when only one additional digit was present, it would be on the outside of the fore foot.

The tendency to interference would seem to be another reason against the retention of the inner digit. Possibly the additional protection which an inside hooflet would receive, might more than counterbalance this influence. Again, the above law is not known to apply to the perissodactyle foot, beyond the first and fifth digits, and if the second digit was originally of greater use than the fourth, and hence was longer retained, an ancestor of the horse may yet be found with the second and third toes alone developed.

In considering these double hoofs of the horse, and with them the well known cleft in the coffin bone of recent and extinct equines, it is important to understand that in no case do they indicate any approach to the true artiodactyle type, as some authors have supposed. The difference between the perissodactyle, or "odd-toed," and artiodactyle, or "even-toed," structure is a profound one, extending to nearly every part of the skeleton, and marking two distinct groups of Ungulates. The number of toes has really nothing to do with the true distinction, and hence the terms in use are especially misleading. The real difference, so far as the feet are concerned, is, that in the perissodactyle type the axis of the limb passes through the middle of the third digit (*Mesaxonia*), while in artiodactyles it is outside of this digit (*Paraxonia*), between it and the fourth.

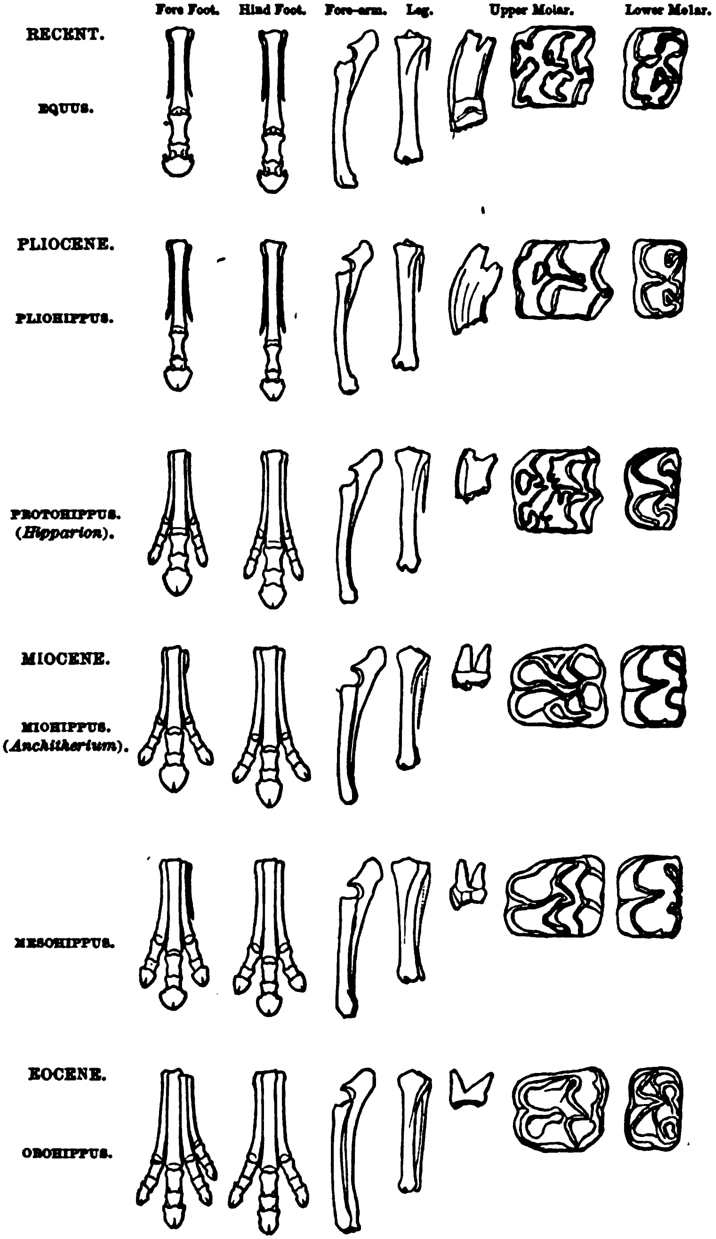
If, now, we turn back to the early ancestors of the horse for an explanation of the supplementary digits which so often make their appearance, we shall not look in vain, especially in this country. America is the original home of the horse, and during the whole of Tertiary time, this continent was occupied with equine mammals, of many and various forms. Although all these became extinct before the discovery of this country, their abundant remains mark out the genealogy of the horse in an almost unbroken succession of forms.

If we examine the remains of the oldest representatives of the horse in this country, we shall find that these animals were all polydactyle, and of small size. As the line was continued towards the present era, there was a gradual increase in size, and a diminution in the number of toes, until the present type of horse was produced. In view of the facts mentioned in the preceding pages, it will be profitable to trace the main line of descent in this group, from its first appearance to the present period, and note especially the changes in the number of digits. For this purpose the diagram on page 505 will be instructive, as it records the principal stages in the series, both of the limbs and the teeth as well. This diagram was prepared by the writer for Professor Huxley, who used it first in his New York lectures. The specimens figured are all in the Yale Museum.

The original ancestor of the horse, not as yet discovered, undoubtedly had five toes on each foot. The oldest member of the group now known is the *Eohippus*, which had four well developed toes and the rudiment of another on each fore foot, and three toes behind. This animal was about as large as a fox, and its remains are from the Coryphodon beds, near the base of the Eocene. It is not represented on page 505, as it was found since the diagram was made. In the next higher division of the Eocene, another equine genus, *Orohippus*, makes its appearance. It resembled its predecessor in size, but had only four toes in front and three behind, as shown in the lowest series of the diagram. At the top of the Eocene, a third allied genus has been found (*Epihippus*), which closely resembled *Orohippus* in its digits, but differed in its teeth.

Near the base of the next formation, the Miocene, another equine mammal, *Mesohippus*, occurs. This animal was about as large as a sheep, and had three usable toes and the splint of another, on each fore foot, with but three toes behind, as shown in the diagram. At a somewhat higher horizon, a nearly allied genus, *Miohippus*, has been found, which has the splint bone of the outer or fifth digit reduced to a short remnant. In the Pliocene above, a three toed horse (*Protohippus*) about as large as a donkey was abundant, and still higher up a near ally of the modern horse, with only a single toe on each foot, (*Pliohippus*) makes his appearance. A true *Equus*, as large as the existing horse, appears just above this horizon, and the series is complete.

Yale College, New Haven, May 15th, 1879.



GENEALOGY OF THE HORSE.

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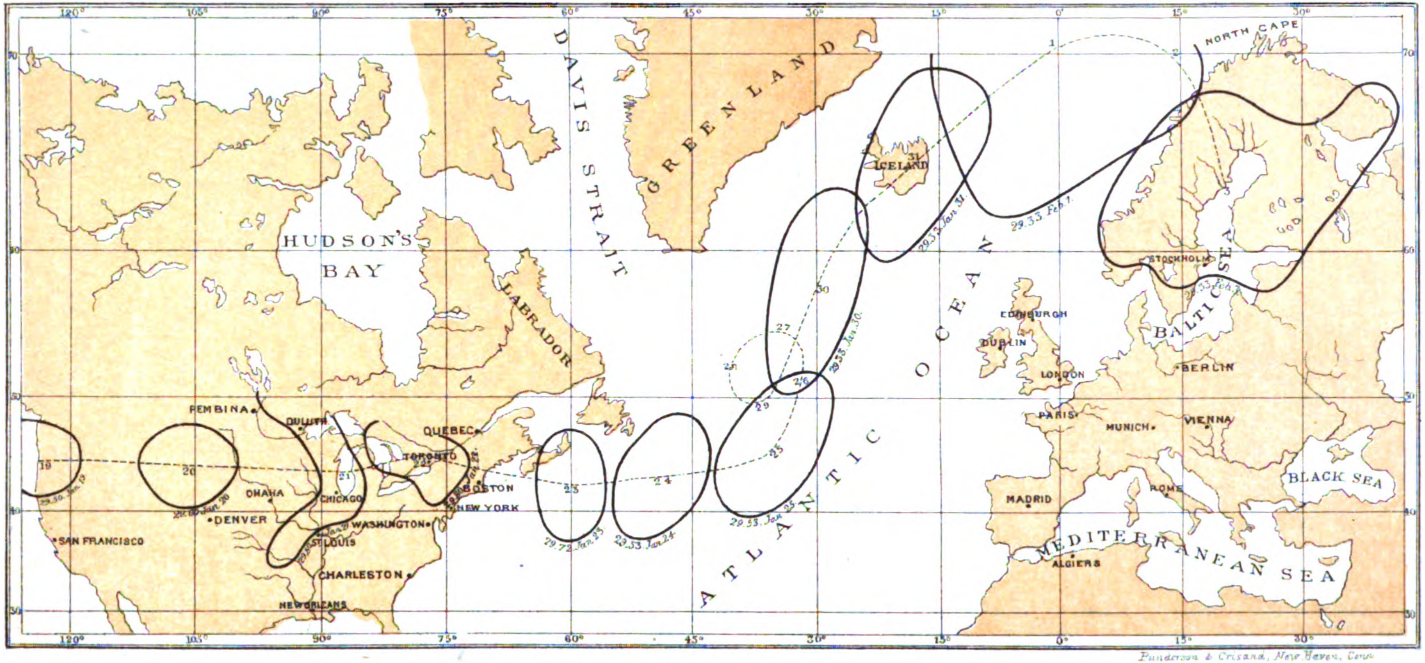
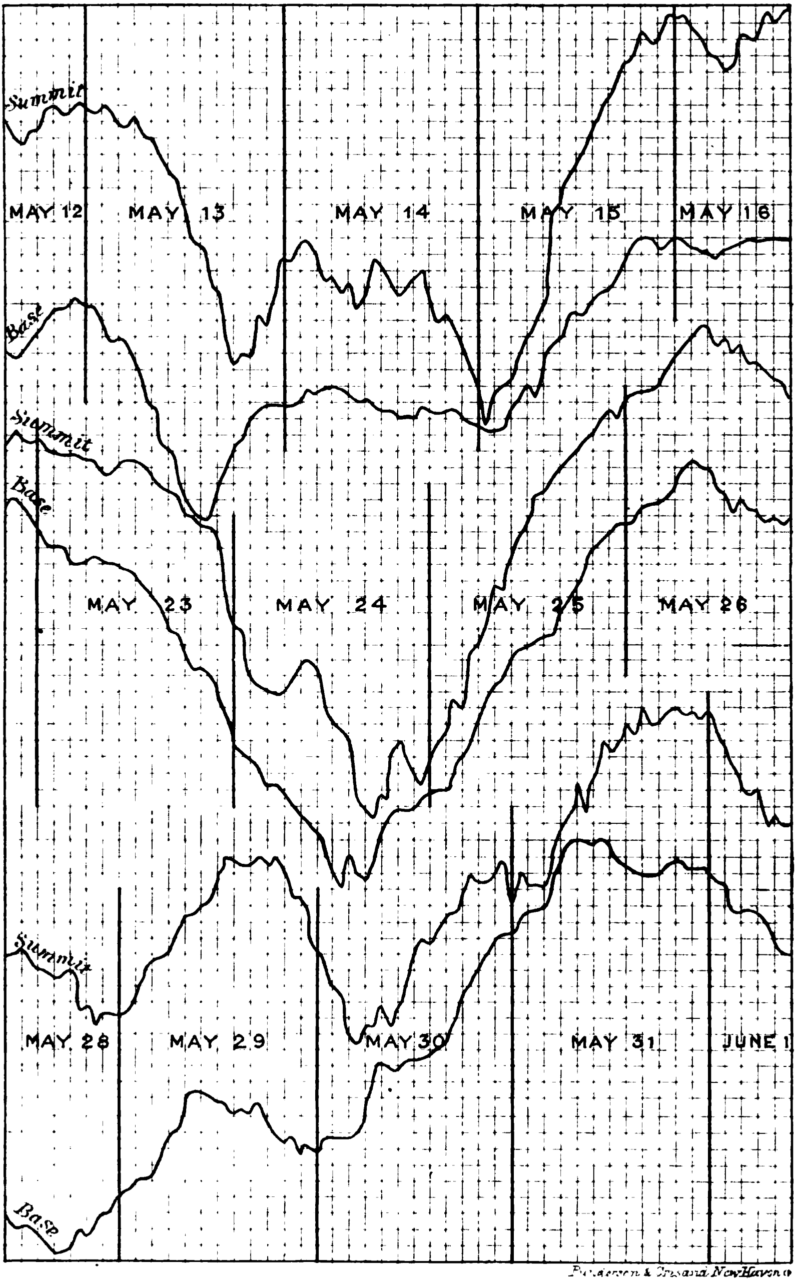
STORM OF JAN. 19 - FEB. 3. 1875. PLATE I.



Punderson & Crisand, New Haven, Conn.

BAROMETRIC FLUCTUATIONS AT SUMMIT AND BASE OF M^{T} WASHINGTON MAY 12 TO JUNE 1. 1873.

PLATE II.



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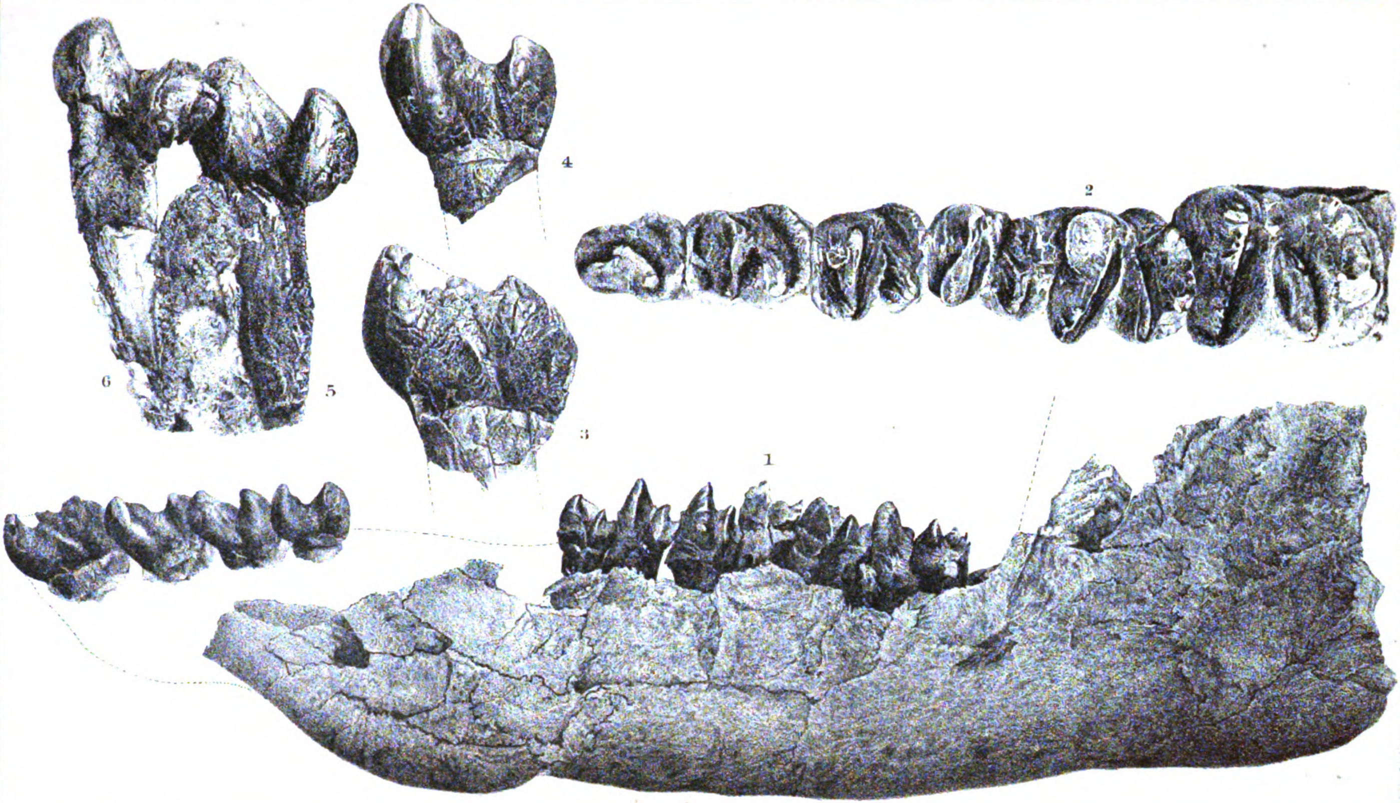

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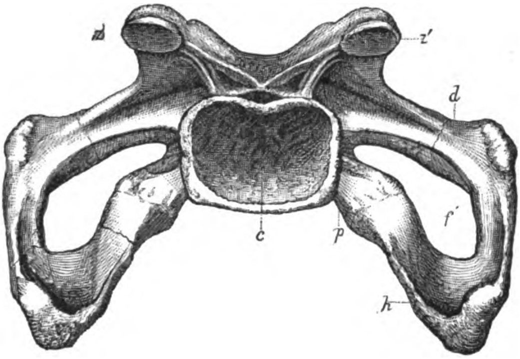

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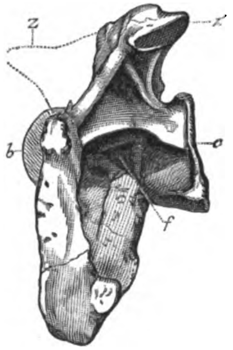

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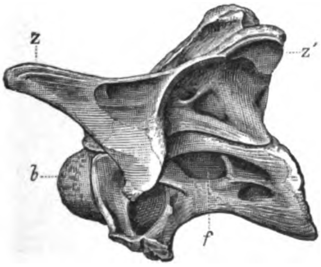

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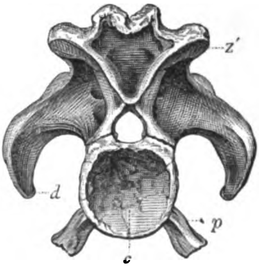
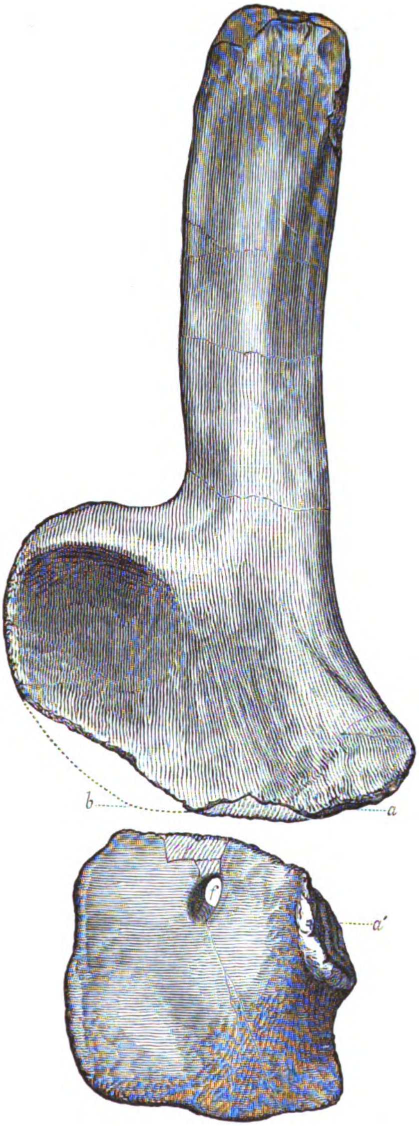


Figure 1.—Cervical vertebra of *Apatosaurus laticollis* Marsh; back view.
Figure 2.—The same; side view. Both one-sixteenth natural size.
Figure 3.—Fourth cervical vertebra of *Morosaurus grandis* Marsh; side view, one-eighth natural size.
Figure 4.—The same; back view.
The signification of the letters is the same in all the figures, viz: *b.* ball; *c.* cup; *d.* diapophysis; *p.* parapophysis; *h.* hatchet bone; *f.* foramen in centrum; *f′.* lateral foramen; *z.* anterior zygapophysis; *z′.* posterior zygapophysis.



Left scapula and coracoid of *Apatosaurus ajax* Marsh; one-fourteenth natural size. *a.* scapular face of glenoid cavity; *b.* rugose surface for union with coracoid; *a′* coracoidean part of glenoid cavity; *f.* foramen in coracoid.

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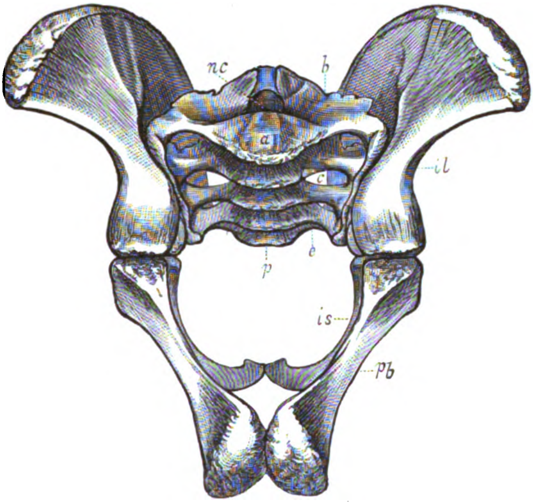

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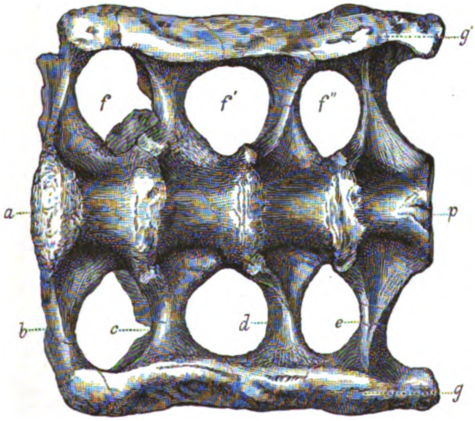

Figure 1.—Pelvic arch of *Morosaurus grandis* Marsh; seen from in front. One-sixteenth natural size.

Figure 2.—Sacrum of *Morosaurus grandis;* seen from below. One-tenth natural size.

a. first sacral vertebra; *b.* transverse process of first sacral vertebra; *c.* transverse process of second vertebra; *d.* transverse process of third vertebra; *e.* transverse process of last sacral vertebra: *f.* foramen between processes of first and second vertebra; *f'.* foramen between second and third processes; *f".* foramen between third and last process; *g.* surface for union with right ilium; *g'.* same for left ilium; *p.* fourth, or last, sacral vertebra: *nc.* neural canal; *il.* ilium; *is.* ischium; *pb.* pubis.

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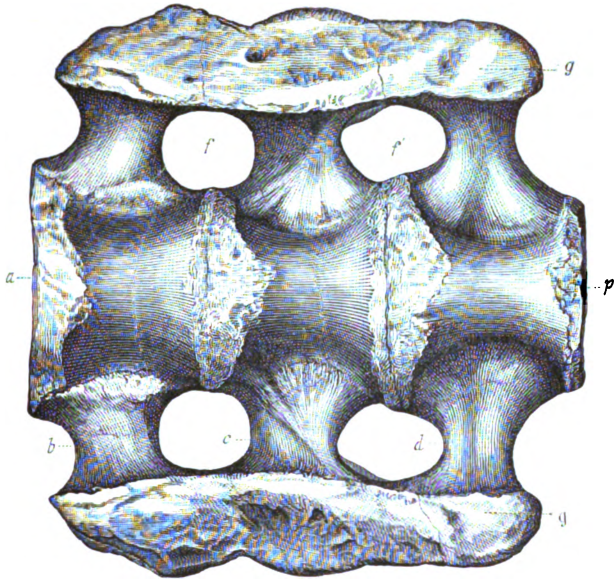

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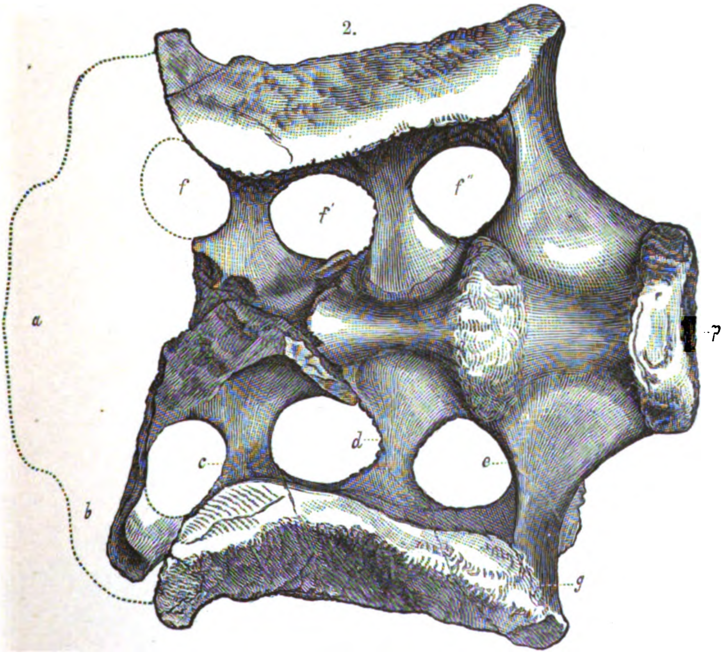
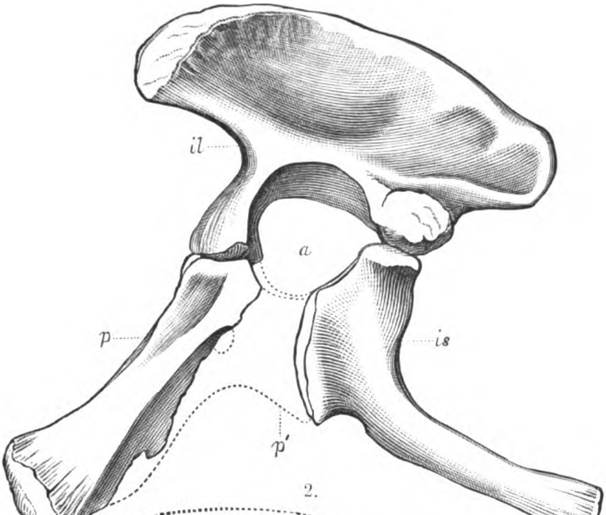


Figure 1.—Sacrum of *Apatosaurus ajax* Marsh; seen from below.

Figure 2.—Sacrum of *Atlantosaurus montanus* Marsh; seen from below; both one-tenth natural size.

a. first sacral vertebra; *b.* transverse process of first vertebra; *c.* transverse processes of second vertebra; *d.* transverse process of third vertebra; *f.* foramen between first and second transverse processes; *f'.* foramen between second and third processes; *p.* last sacral vertebra; *g.* surface for union with ilium.

1.



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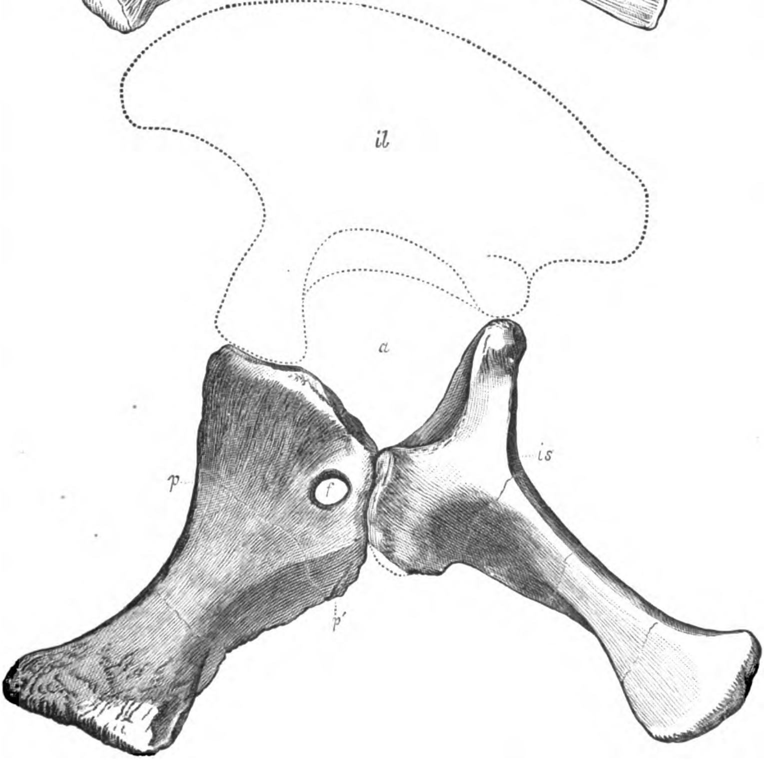
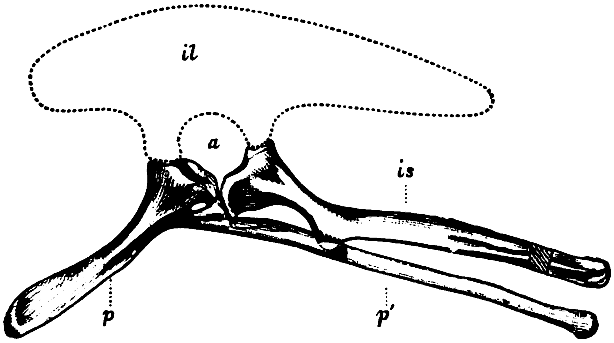


Figure 1.—Pelvis of *Morosaurus grandis* Marsh; seen from the left, one-sixteenth natural size.

Figure 2.—Pelvis of *Atlantosaurus immanis* Marsh; seen from the left, one-twentieth natural size. The signification of the letters is the same in both figures, viz: *a.* acetabulum; *f.* foramen in pubis; *il.* ilium; ***is.*** ischium; ***p.*** pubis; ***p'.*** post-pubis. In these and the following diagrams of Dinosaurian pelves, the three bones of each are represented nearly in the same plane.

1.



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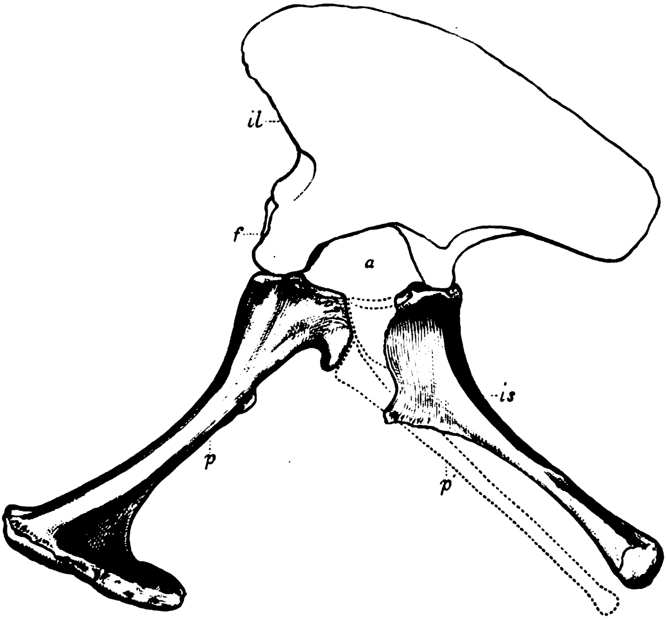
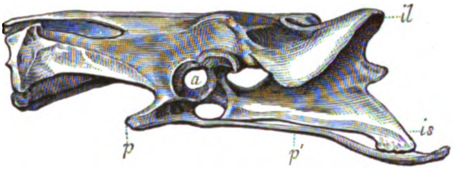


Figure 1.—Pelvis of *Laosaurus altus* Marsh; seen from the left, one-sixth natural size.

Figure 2.—Pelvis of *Allosaurus fragilis* Marsh; seen from the left, one-twelfth natural size. The outline of the ilium is taken from *Creosaurus atrox* Marsh.

The signification of the letters is the same in both figures, viz: *a.* acetabulum; *il.* ilium; *is.* ischium; *p.* pubis; *p′.* post-pubis; *f.* articular facet on front of pubic process of ilium.

1.



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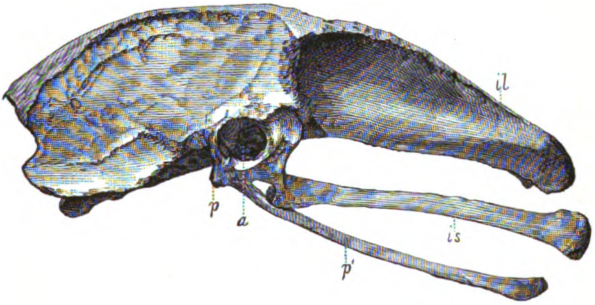

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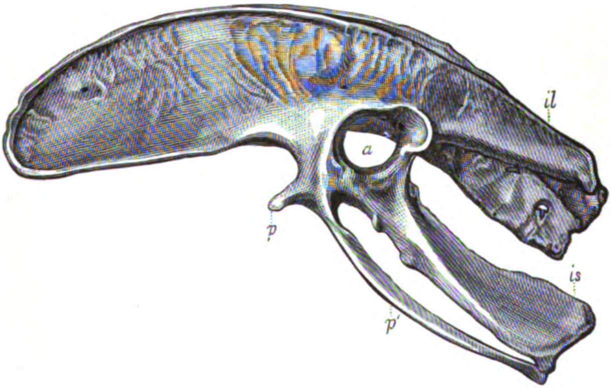
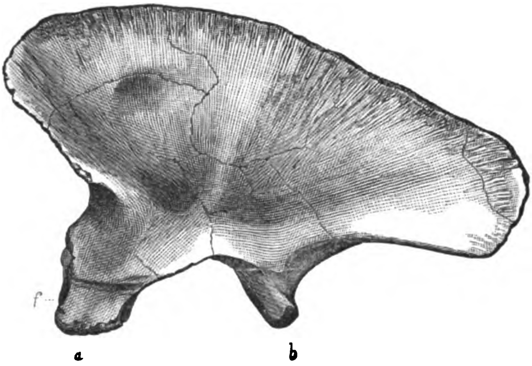


Figure 1.—Pelvis of *Geococcyx Californianus* Baird; seen from the left, natural size.
Figure 2.—Pelvis of Emeu, *Dromaius novæ hollandiæ* Lath; one-fifth natural size.
Figure 3.—Pelvis of *Apteryx australis* Owen; three-fourths natural size.
a. acetabulum; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* post-pubis.

1.



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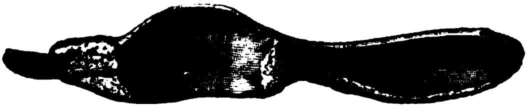

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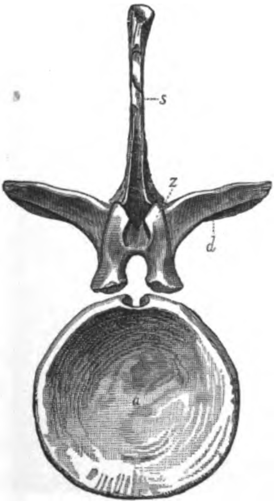

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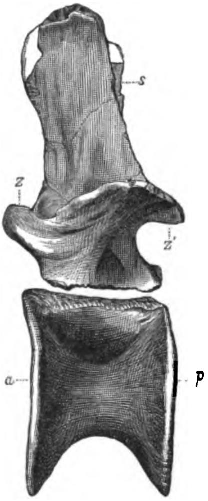

Figure 1.—Left ilium of *Creosaurus atrox* Marsh; seen from the left.
Figure 2.—The same; seen from below. Both one-tenth natural size.
a. anterior, or pubic, articulation; *b.* posterior, or ischiadic, articulation; *f.* articular facet on front of pubic process.
Figure 3.—Lumbar vertebra of *Allosaurus fragilis* Marsh; front view.
Figure 4.—The same; side view, from the left. Both one-sixth natural size.
a. anterior articular face; *p.* posterior articular face; *s.* neural spine; *d.* diapophysis; *z.* anterior zygapophysis; *z'.* posterior zygapophysis.

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THE

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[THIRD SERIES.]

Art. I.—*Contributions to Meteorology, being results derived from an examination of the Observations of the United States Signal Service and from other sources;* by Elias Loomis, Professor of Natural Philosophy in Yale College. Eleventh paper. With plates I and II.

[Read before the National Academy of Sciences, Washington, April 15, 1879.]

The Winds on Mt. Washington compared with the winds near the level of the sea.

In my last Article I gave some reasons for believing that areas of low pressure sometimes result from a circulation of the surface winds which does not extend to the height of 6,000 feet. In order to investigate this subject more fully, I selected from the published volumes of the Signal Service observations all those cases in which the direction of the wind on Mt. Washington differed at least 90° from that at each of the stations, Burlington, Boston, and Portland, Me. The number of these cases was 507. Three-fifths of these cases occurred when the wind on Mt. Washington was from the west or northwest, and more than four-fifths of them occurred when the wind on Mt. Washington was from one of the points N., N.W., W. or S.W.; and at the same time the wind at the neighboring surface stations was generally from one of the points S., S.E., E. or N.E. As this Table, if accompanied with the details necessary to render it intelligible, is too large for publication, I have adopted a different standard of selection, and have taken all those cases in which the barometer at Portland, Me., fell as low as 29·6 inches. This list has already been given in my tenth paper, page 9, except that I have added the cases found in the volumes of observations since published for January, February and

Table I.—*Winds on Mt. Washington compared with the surface winds.*

	1872.						
1	Oct.	12.2 S.W. 5	12.3 W. 30	13.1 S.W. 27	13.2 N.W.30	13.3 N. 59	14.1 S.W. 22
		S. 4	S. 6	S. 9	S.E. 12	N.E. 8	*N. 4
2		25.3 N.W.15	26.1 S.E. 24	26.2 S.W. 29	26.3 S.W. 18	27.1 N.E. 4	27.2 N.E. 29
		E. 2	N.E. 6	N.E. 5	N.E. 7	*N. 8	N. 8
3	Nov.	6.1 N.W.20	6.2 N.W.28	6.3 N.W.30	7.1 S.E. 4	7.2 S.W. 38	7.3 N.W.65
		S. 3	S. 9	S. 8	S.E. 3	*W. 9	W. 8
4		11.1 calm.	11.2 W. 13	11.3 S.E. 50	12.1 S.W. 28	12.2 S.W. 65	12.3 N. 50
		S. 2	S. 10	S. 7	S. 8	S. 8	*N. 14
5		13.2 N.W. 5	13.3 S. 15	14.1 W. 55	14.2 S. 30	14.3 W. 32	15.1 W. 38
		N. 4	S.E. 4	S.E. 5	S.E. 5	*W. 4	W. 10
6		28.3 S.W. 22	29.1 N.E. 22	29.2 S.W. 35	29.3 S.W. 22	30.1 N.E. 45	30.2 S.W. 27
		S. 4	S.E. 9	N.W. 9	W. 10	*W. 13	S.W. 14
7	Dec.	1.3 W. 32	2.1 S.E. 25	2.2 W. 35	2.3 S. 42	3.1 S.E. 51	3.2 S.E. 60
		S. 5	S. 4	S. 4	S.W. 5	*W. 13	W. 9
		3.3 S.E. 42	4.1 W. 58			9.3 S.E. 16	10.1 W. 59
		W. 7	W. 9			N.W.15	N.W.15
8		7.3 W. 8	8.1 S.E. 49	8.2 S.E. 54	8.3 N.W.22	9.1 calm.	9.2 S.W. 10
		S. 7	S. 9	S. 8	S. 5	S. 2	*N.W.10
9		26.1 N.W.16	26.2 N.E. 2	26.3 S. 5	27.1 calm.	27.2 N.W.24	27.3 S.W. 41
	1873.	N.E. 5	N.E. 10	N. 8	N.W. 5	*N.W. 7	N.W.10
10	Jan.	2.2 S.W. 38	2.3 S. 36	3.1 S.W. 48	3.2 W. 36	3.3 W. 42	4.1 S.W. 56
		N.E. 3	N.E. 5	S. 5	S.W. 6	*W. 4	W. 8
11		4.3 W. 50	5.1 W. 36	5.2 S. 64	5.3 S. 60	6.1 W. 32	6.2 W. 60
		W. 5	N.E. 2	N.E. 13	*N.E. 4	W. 12	W. 9
12		20.3 S.W. 54	21.1 W. 16	21.2 S.W. 28	21.3 S.W. 34	22.1 S.W. 26	22.2 N.W.40
		S. 5	S. 1	S. 6	N.E. 4	*N.W. 4	N.W. 7
13		26.2 W. 10	26.3 N.W.28	27.1 N. 10	27.2 S.W. 6	27.3 S.W. 16	28.1 W. 28
		W. 3	E. 2	E. 1	N.E. 7	*N. 7	S.W. 5
14	Feb.	3.1 W. 44	3.2 S.W. 40	3.3 W. 32	4.1 S.W. 46	4.2 W. 44	4.3 W. 64
		S.W. 11	S.W. 6	S. 6	S. 7	*S.W. 6	N.W. 6
15		6.3 W. 44	7.1 W. 14	7.2 S. 30	7.3 S. 34	8.1 S.W. 18	8.2 S.W. 50
		S.W. 4	N. 2	N.E. 5	N.E. 10	*W. 8	W. 6
16		21.1 W. 40	21.2 S. 38	21.3 S. 12	22.1 S.E. 26	22.2 S.E. 36	22.3 W. 52
		N.E. 3	E. 12	*N.E. 12	W. 12	N.W.12	N.W. 9
17	March.	2.3 W. 12	3.1 W. 37	3.2 N.E. 30	3.3 N.E. 42	4.1 S.E. 48	4.2 N.W.36
		N.W. 3	N. 8	*N.E. 13	N. 15	N. 9	N.W. 7
18		7.2 W. 36	7.3 W. 50	8.1 W. 16	8.2 S. 46	8.3 N.W.126	9.1 N.W.89
		S. 6	S. 8	S. 9	S. 8	*W. 8	W. 12
19		15.1 W. 12	15.2 S.W. 17	15.3 S. 38	16.1 S. 38	16.2 S.W. 52	16.3 W. 28
		S. 5	S. 8	S.E. 8	*S. 8	W. 13	N.W.18
20		20.1 N.W. 5	20.2 S.E. 2	20.3 S.E. 84	21.1 S.E. 50	21.2 W. 12	21.3 W. 29
		E. 6	E. 7	N.E. 14	*W. 10	W. 10	W. 11
21		22.2 W. 32	22.3 W. 41	23.1 N.W.38	23.2 W. —	23.3 N.W.43	24.1 W. 48
		W. 5	W. 7	S.W. 4	S. 8	*W. 9	N.W. 9
22		25.2 S.W. 24	25.3 S.W. 40	26.1 S.W. 23	26.2 S. 54	26.3 W. 35	27.1 N.W.60
		N.E. 4	N.E. 5	N.E. 10	N.E. 9	*N. 8	N.W.12
23		28.3 W. 76	29.1 S.W. 34	29.2 S.W. 17	29.3 S.W. 50	30.1 W. 18	30.2 W. 44
		S. 8	S. 5	S.E. 12	S. 13	*N. 7	W. 17
24		30.3 N.W.24	31.1 N.W.42	31.2 S. 24	31.3 S. 82	32.1 S. 20	32.2 N.W.14
		S.W. 2	S. 4	*N. 9	W. 9	W. 4	W. 4
25	April.	11.3 N.W.10	12.1 S. 36	12.2 N.E. 70	12.3 E. 96	13.1 N.E. 58	13.2 N.W.46
		N.E. 3	N.E. 7	N.E. 10	N.E. 11	N.E. 11	N. 10
26		18.1 N. 60	18.2 S.E. 20	18.3 S.E. 6	19.1 calm.	19.2 W. 36	19.3 W. 24
		N.E .10	N.E. 8	N.E. 4	N. 5	*N. 5	N. 1
27		24.3 N. 5	25.1 W. 12	25.2 S.E. 5	25.3 S.E. 5	26.1 S.E. 10	26.2 W. 46
		W. 7	W. 6	W. 6	W. 4	*N.W. 7	N.W.10
28	May.	12.1 N. 22	12.2 N.W.40	12.3 N.W.56	13.1 W. 44	13.2 N.W.51	13.3 N.W.48
		N.W. 4	N.W. 5	S. 5	S. 7	*W. 8	W. 6
29		23.1 W. 24	23.2 W. 13	23.3 W. 60	24.1 W. 40	24.2 W. 60	24.3 W. 72
		S. 4	S. 9	S. 9	S. 7	*W. 7	N.W. 6

Winds on Mt. Washington compared with the surface winds.

	1873.						
30	June.	3.1 N.W. 6	3.2 W. 14	3.3 W. 10	4.1 N.W.24	4.2 W. 36	4.3 N.W.30
		N.E. 8	E. 6	S. 7	S. 7	S. 8	*N. 5
31		18.3 N.W.48	19.1 N.W.24	19.2 W. 30	19.3 W. 41	20.1 N.W.26	20.2 N.W.36
		S.W. 7	S.W. 4	S.W. 5	S. 7	*W. 6	N.W.12
32	Sept.	0.1 W. 40	0.2 N.W.30	0.3 N.W.10	1.1 S.W. 20	1.2 S.W. 50	1.3 N.W.60
		S.W. 5	W. 2	N.E. 3	S. 7	*W. 10	W. 12
33	Oct.	6.1 N.W.35	6.2 S.W. 8	6.3 S.W. 18	7.1 N.E 12	7.2 N.E. 20	7.3 N. 30
		S.E. 3	N.E. 7	N. 10	*N. 11	N. 7	N. 6
34		10.3 S. 20	11.1 S. 20	11.2 S.E. 18	11.3 S.E. 20	12.1 S.W. 10	12.2 W. 20
		S. 3	S. 4	S. 6	S. 4	W. 3	*W. 8
35		26.1 N.W.20	26.2 N.W. 8	26.3 N.W.45	27.1 S.W. 55	27.2 N.W.35	27.3 N.W.45
		S.W. 3	S. 7	S. 12	S. 16	*W. 12	N.W. 8
36	Nov.	6.3 N.W.38	7.1 N.W.38	7.2 S.W. 12	7.3 calm.	8.1 S.E. 30	8.2 N.W.28
		E. 5	S. 4	S.E. 9	S.E. 6	N.E. 9	*W. 6
37		11.2 N.W.34	11.3 N.W.10	12.1 S.E. 46	12.2 W. 22	12·3 N.W.28	13.1 W. 30
		S. 4	S. 3	S.E. 12	W. 6	*W. 5	N.W,12
38		15.3 N.W. 6	16.1 N.W.30	16.2 S.E. 34	16.3 S.E. 10	17.1 S.E. 6	17.2 S.E. 22
		E. 3	N.E. 4	N.E. 7	N.E. 7	N.E. 7	N.E. 10
				17.3 S.E. 56	18.1 E. 48	18.2 S.E. 5	18.3 N.W.49
				N.E. 14	N.W.17	*N.W.12	N.W. 7
39	Dec.	2.3 S.W. 40	3.1 S.W. 42	3.2 W. 52	3.3 S.W. 47	4.1 S.W. 65	4.2 W. 80
		S. 10	S. 6	S. 12	S. 11	S. 16	*W. 12
40		12.2 N.W.28	12.3 N.W.23	13.1 calm.	13.2 S.E. 23	13.3 calm.	14.1 N.W.65
		W. 3	N. 4	N.E. 7	N.E. 11	*N. 11	N.W. 8
41		25.2 N.W.28	25.3 N.W. 3	26.1 N.W.22	26.2 E. 24	26.3 calm.	27.1 N.W.28
		N. 5	N.E. 3	N.E. 5	N.E. 8	*N. 9	N. 7
42		27.1 N.W.28	27.2 N. 10	27.3 S.E. 24	28.1 N.E. 28	28.2 N.W.96	28.3 N.W.85
	1874.	N. 7	N.E. 6	N.E. 11	*N.W.17	N.W.12	N.W. 6
43	Jan.	7.2 S.W. 54	7.3 S.W. 46	8.1 S.E. 62	8.2 S.W. 46	8.3 S.W. 45	9.1 N.W.35
		N. 4	N.E. 1	S. 13	*S. 15	S.W. 10	S.W. 6
44		9.1 N.W.35	9.2 N.W.16	9.3 N.W.25	10.1 S.W. 45	10.2 W. 30	10.3 W. 15
		S.W. 6	S. 5	S. 2	S. 7	*S.W. 5	S.W. 3
45		13.2 N.W.10	13.3 S. 15	14.1 S.E. 34	14.2 N.W.10	14.3 N.W.48	15.1 N.W.42
		N. 3	E. 4	N. 16	N. 13	N.W. 7	N.W. 5
46		21.3 N.W.64	22.1 S.W. 58	22.2 W. 60	22.3 S.W. 52	23.1 W. 37	23.2 W. 80
		S. 4	S. 8	S. 6	S. 12	S. 12	*S.W. 13
47		26.3 N.W.68	27.1 N.W.35	27.2 N.W.32	27.3 W. 10	28.1 N.W.25	28.2 S.W. 50
		N. 1	S. 8	S. 7	S. 8	S. 3	*N.W. 9
48	Feb.	9.2 N.W. 8	9.3 S.W. 4	10.1 N.W. 2	10.2 N.W.45	10.3 N.W.82	11.1 N.W.90
		calm.	calm.	N.W. 5	N.W.11	*N.W.12	N.W. 7
49		12.2 N.W.36	12.3 S.W. 20	13.1 S.W. 44	13.2 S.W. 48	13.3 S.W. 58	14·1 W. 72
		E. 5	S. 8	S. 11	S. 14	S. 14	*W. 12
50		15.1 N.W.19	15.2 S. 32	15.3 S. 40	16.1 S.W. 18	16.2 N.W.55	16.3 N.W.72
		N. 5	S. 10	S. 12	S. 12	S.W. 12	*W. 16
51	March.	2.3 N.W.56	3.1 N.W.38	3.2 S.W. 60	3.3 S.W. 96	4.1 S.W. 74	4.2 N.W.52
		S. 11	S. 8	S. 11	S. 9	S. 13	*N.W.14
52		8.1 N.W.54	8.2 N.W.50	8.3 N.W.58	9.1 N.W.50	9.2 N.W.20	9.3 N. 23
		S. 6	W. 10	W. 11	W. 15	*N.W.15	N.W.13
53		18.1 W. 50	18.2 W. 36	18.3 W. 14	19.1 W. 10	19.2 W. 44	19.3 W. 77
		S. 9	S. 6	S. 2	S. 2	S. 12	*W. 11
54		21.2 N.W.38	21.3 N.W.37	22.1 N.W.40	22.2 N.W.47	22.3 N.W.20	23.1 N.W.74
		S.W. 14	S.W. 9	W. 8	N.W.13	*S. 7	N.W.18
55		25.2 N.W.54	25.3 N.W.78	26.1 N.W.48	26.2 N.W.34	26.3 N.W.59	27.1 N.W.67
		S.W. 23	S.W. 19	S. 8	N. 8	*W. 13	N.W.11
56	April.	1.2 N.W.13	1.3 W. 19	2.1 N.W.15	2.2 S.W. 6	2.3 W. 24	3.1 W. 24
		S. 8	S.E. 5	S. 4	S. 12	S. 10	*W. 8
57		14.1 N.W.55	14.2 W. 36	14.3 W. 47	15.1 N.W.55	15.2 S.W. 52	15.3 N.W.40
		S. 9	S. 13	S. 13	S. 8	*S. 8	W. 13
58		19.3 N.W.72	20.1 E. 6	20.2 S. 60	20.3 S. 36	21.1 N.W.67	21.2 N.W.58
		N. 7	N.E. 11	E. 9	N.E. 14	*S.W. 5	N.W.14
59		24.3 N.W.23	25.1 calm.	25.2 E. 16	25.3 E. 58	26.1 E. 90	26.2 N. 50
		calm.	E. 6	E. 9	E. 13	*N.E. 18	N. 21
60		28.1 N.W.86	28.2 S.E. 2	28.3 S. 5	29.1 E. 35	29.2 E. 18	29.3 N.W.12
		N.W.11	N. 5	calm.	N. 11	N. 17	N. 18

Winds on Mt. Washington compared with the surface winds.

61	1874. May.	4.2 N.W.28 W. 7	4.3 N.W.48 N.W. 6	5.1 N. 19 N.E. 7	5.2 N.W.24 *N.E. 8	5.3 N.W.36 N.W. 5	6.1 N.W.20 N. 8
62		24.2 N.W.18 S. 6	24.3 W. 10 S. 3	25.1 S.W. 56 S.E. 13	25.2 S. 88 S.E. 13	25.3 W. 56 *S.W. 11	26.1 W. 42 S.W. 10
63		30.1 N.W.32 E. 6	30.2 N.W.30 S.E. 7	30.3 W. 36 S. 5	31.1 N.W.38 S. 9	31.2 N.W.50 *S.W. 20	31.3 N.W.40 N. 8
64	June.	6.2 N.W.20 E. 6	6.3 N.W.24 S.E. 3	7.1 N.W.20 S.E. 5	7.2 W. 36 S.E. 8	7.3 W. 68 S. 7	8.1 W. 90 *W. 8
65		16.1 W. 20 S. 3	16.2 S. 36 S. 12	16.3 S. 60 S. 14	17.1 N.W.36 S. 11	17.2 S. 20 S.W. 7	17.3 W. 24 *W. 5
66		22.1 N. 28 S. 8	22.2 N. 44 S. 8	22.3 N.W.42 S.W. 8	23.1 N.W.60 S. 10	23.2 N.W.34 *S.W. 9	23.3 N.W.52 N.W.12
67		27.2 W. 18 S. 9	27.3 W. 23 S. 11	28.1 N.W.25 S. 7	28.2 N. 36 *S. 10	28.3 W. 54 S.W. 11	29.1 N.W.24 S.W. 7
68	Aug.	0.1 N.W.16 S. 5	0.2 S.W. 50 S. 14	0.3 N.W.52 S.W. 11	1.1 N.W.60 S.W. 10	1.2 N.W.75 *W. 9	1.3 N.W.70 N.W. 5
69	Sept.	29.1 W. 16 W. 5	29.2 S.E. 10 N.E. 11	29.3 E. 54 N.E. 8	30.1 N.W.30 *N.W.14	30.2 N.W.84 N.W.13	30.3 N.W.64 W. 12
70	Oct.	1.1 N.W.20 W. 11	1.2 N.W.36 W. 13	1.3.N.W.40 S. 8	2.1 S.W. 38 S. 13	2.2 N.W.25 *S.W. 10	2.3 N.W.56 W. 11
71		9.2 N.W.55 S.W. 8	9.3 N.W.55 S. 5	10.1 S.W. 30 S. 10	10.2 S. 35 S. 11	10.3 W. 40 *S.W. 12	11.1 N.W.54 W. 11
72		16.3 N. 40 S.W. 6	17.1 W. 30 S.W. 6	17.2 W. 28 S.W. 10	17.3 N.W.18 S.W. 7	18.1 N. 24 *N.W. 6	18.2 N. 34 N.W.12
73	Nov.	9.3 N. 56 S.W. 7	10.1 N. 74 W. 9	10.2 N. 70 W. 4	10.3 W. 46 S. 6	11.1 N. 78 *W. 5	11.2 N. 70 N.W.19
74		19.2 N. 50 W. 6	19.3 N. 34 S. 4	20.1 S. 24 S. 5	20.2 S. 60 S. 7	20.3 S. 40 *S. 6	21.1 N.W.30 N.W. 8
75		22.2 N. 8 N. 3	22.3 N.W.18 S.E. 5	23.1 S.E. 54 S.E. 12	23.2 S.E. 35 S.W. 11	23.3 N.W.32 *W. 8	24.1 N. 48 W. 13
76		28.1 N.W.50 S.W. 5	28.2 S.W. 36 N.E. 3	28.3 S. 70 S. 7	29.1 S.W. 60 N.W.13	29.2 N. 84 *W. 6	29.3 N.W.88 W. 11
77	Dec.	16.1 N. 25 calm.	16.2 N.W.38 S.E. 4	16.3 N.W. 8 S.E. 4	17.1 N.W.54 S.E. 7	17.2 N.W.35 W. 7	17.3 N.W.60 *N.W.16
78		22.2 W. 40 S. 10	22.3 W. 40 S. 7	23.1 N. 40 S. 5	23.2 N.W.48 S.W. 5	23.3 N.W.24 S. 8	24.1 W. 40 S.W. 7
79	1875. Jan.	1.1 N.W.80 W. 9	1.2 N.W.45 S. 5	1.3 N.W.48 S. 6	2.1 N.W.14 S. 6	2.2 S.W. 30 *W. 10	2.3 N.W.90 N.W.20
80	1877. Jan.	1.1 N.W.50 W. 7	1.2 N.W.28 N.W. 2	1.3 calm. N.E. 8	2.1 N. 17 *N. 16	2.2 N. 56 N.W.19	2.3 N. 70 N.W.10
81		6.1 N.W.48 S. 3	6.2 N.W.42 S. 8	6.3 N.W.40 N.E. 3	7.1 N.E. 50 N.E. 12	7.2 N.W.96 *W. 15	7.3 N.W.60 W. 9
82		7.3 N.W.60 W. 9	8.1 N.W.60 S. 8	8.2 N.W.48 S. 15	8.3 N.W.54 *W. 19	9.1 N.W.96 N.W. 9	9.2 N.W.60 N.W. 5
83		19.1 N.W.46 calm.	19.2 N.W.46 S. 3	19.3 N.W.62 S. 6	20.1 W. 48 S. 16	20.2 N.W.86 *W. 24	20.3 N.W.96 W. 14
84	Feb.	15.3 N.W.50 S. 9	16.1 N.W.24 S.W. 6	16.2 W. 36 S.W. 8	16.3 W. 24 W. 7	17.1 N. 24 W. 14	17.2 N.W.60 N.W.17
		17.3 N.W.72 W. 13	18.1 N.W. 108 *W. 21			25.1 N.E. 24 *N. 11	25.2 N. 24 N. 12
85		23.1 N.W. 6 N.E. 5	23.2 N.E. 12 N.E. 4	23.3 N.E. 30 N.E. 7	24.1 N.E. 54 N.E. 16	24.2 N.E. 36 N.E. 17	24.3 N.E. 60 N.E. 18
86	March.	1.2 N.W.60 W. 7	1.3 N.W. 6 S. 5	2.1 S.W. 38 S.E. 11	2.2 S. 60 S. 13	2.3 S.W. 48 *S. 15	3.1 N.W.84 W. 12
87		7.3 N.W.66 N. 3	8.1 W. 42 S. 7	8.2 W. 54 S. 7	8.3 W. 72 S. 13	9.1 W. 66 S.E. 27	9.2 W. 54 *W. 31
88		12.2 N.W.72 S. 6	12.3 calm. calm.	13.1 N.E. 6 N.E. 12	13.2 N.E. 6 N.E. 8	13.3 N.E. 4 calm.	14.1 S. 12 N.E. 8
		14.2 S. 60 S.E. 12	14.3 W. 40 S. 10	15.1 N.W.18 N.W.10	15.2 N.W.72 *W. 18		
89		25.2 W. 24 N.E. 13	25.3 S.W. 24 E. 10	26.1 S.E. 72 N.E. 10	26.2 E. 48 N.E. 11	26.3 S.E. 78 N.E. 10	27.1 S.E. 60 N.E. 9
		27.2 S.E. 60 N. 9	27.3 S.E. 66 N. 3	28.1 S.E. 54 N. 11	28.2 S.E. 24 *N. 14	28.3 N.E. 18 N.W. 9	29.1 N.E. 10 N.W.14

March, 1877 The total number of these cases is 89, and they are shown in Table I, in which two lines are given for each date; the first horizontal line shows the direction and force of the wind on Mt. Washington for six observations near the time of barometric minimum, and the second line shows for the same dates the average direction and force of the wind at five or six of the nearest surface stations. These data are designed to indicate the average direction of the surface winds near the base of Mt. Washington as accurately as it can be derived from the observations. For each case, the date of minimum pressure at the neighboring surface stations is indicated by an asterisk.

It will be noticed that for several observations preceding the minimum pressure, the surface winds generally blew from one of the points S., S.E., E. or N.E.; and that about the time of minimum pressure the wind changed to one of the points N., N.W., W. or S.W. For convenience I call the semicircle including the four former directions the *east quarter*, and the semicircle including the four latter directions the *west quarter*. On the summit of Mt. Washington we sometimes notice a similar change of wind near the time of minimum pressure, but not invariably. There are two cases in which the change of wind from one of the above mentioned quarters to the other did not occur in a decided manner either at the base or summit of Mt. Washington. These cases are Nos. 48 and 72. In each of these cases however there were a few of the surface stations at which the wind blew for a short time from the east quarter. In No. 48 at 9.2 the wind at Boston was east, while at Burlington and Portland it was south, but the velocity at all of the stations was so small that I have preferred to record it as a calm. The center of this depression was on the southeast side of Mt. Washington. In No. 72 the winds preceding the minimum pressure at several stations blew from the south, but the prevalent direction appeared to be S.W. This low center passed on the north side of Mt. Washington. These two cases should properly be deducted from the total number of cases, leaving the number of cases considered in the subsequent comparisons 87.

There were 40 cases in which the change of wind from the west to the east quarter was felt at the base but not at the summit of Mt. Washington, that is, 46 per cent of the whole number of cases; and there were two cases in which this change occurred at the summit but did not occur in a decided manner at the base. These cases are Nos. 27 and 60. In No. 27 at 25.1 the wind at Burlington was south, and at Portland was northeast, but the prevalent direction of the surface winds in the vicinity of Mt. Washington appeared to be west. It will also be observed that the wind at this time on Mt. Washington was very feeble. In No. 60 the wind at Boston at 28.3 blew from east, and at 29.1 from northeast, but there was no prevalent surface wind from the east quarter. The center of this low area passed on the south side of Mt. Washington. We thus see that occasionally when a low center passes near Mt. Washington, there is no prevalent surface wind from the east quarter although it occurs on Mt. Washington; but out of 87 cases which have been examined only two cases of this kind have been found; while in nearly half of the whole number of cases the surface wind blew for a time from the east quarter, but on the summit of Mt. Washington it blew uninterruptedly from the west quarter. In other words, in about half of the cases in which the barometer in New England sinks to 29·6 inches, the usual change of wind to the east quarter is observed at the surface stations, but this change does not reach to the summit of Mt. Washington.

We have now 45 cases in which the change of wind from the west quarter to the east occurred both at the summit and base of Mt. Washington. In 37 of these cases the change occurred first at the base, and in 8 cases the change occurred simultaneously at the summit and the base; that is, at an interval of less than 8 hours; and taking the average of all the cases we find that the change of wind at the surface stations usually occurs eleven hours earlier than it does on Mt. Washington.

In 23 cases the change of the wind back from the east quarter to the west quarter occurred simultaneously on the summit of Mt. Washington and at the base; that is, with an interval less than 8 hours; in 16 cases the change occurred first at the base, and in 6 cases the change occurred first at the summit. These six cases were Nos. 4, 10, 43, 50, 86 and 88. In four of these cases the wind on Mt. Washington blew from the east quarter at but a single observation, while at the surface stations the east wind continued during a period of from three to five observations, indicating that the influence of the movement of the lower stratum of the air was sensible on Mt. Washington for a few hours only, and then subsided. No. 88 is the only one of these cases in which the wind on Mt. Washington blew from the east quarter during more than two observations. Taking the average of all the cases we find that the change of wind back from the east to the west quarter generally occurs at the base of Mt. Washington sooner than on the summit by five hours.

If we take the average of the pressures at the center of those low areas in which the change of wind to the east quarter did not occur on the summit of Mt. Washington, we obtain the value 29·47 inches. If we take the average of the pressures at the center of those low areas in which the change of wind to the east quarter did occur on Mt. Washington we obtain 29·27 inches, which seems to indicate that the greater the depression of the barometer, the greater is the height to which the system of circulating winds extends. It is, however, remarkable that in several of those cases in which the change of wind to the east quarter did not occur on Mt. Washington the depression of the barometer was very great. During the period of 32 months under examination, there were 8 cases in which the barometer fell below 29 inches: viz. Nos. 23, 38, 42, 60, 75, 81, 83 and 87, and in three of these cases, viz: Nos. 23, 83 and 87, no considerable change of wind occurred on Mt. Washington. In No. 23 the wind on Mt. Washington blew uninterruptedly from the west or southwest although the center of the low area passed south of that station. In Nos. 83 and 87 the wind on Mt. Washington was strong from the west or northwest.

I have also made a comparison of those cases in which an area of low pressure has passed over New England, when the barometer at Portland, Me., did not fall to 29·6 inches, and in seven-eighths of these cases during the continuance of this low pressure the wind on Mt. Washington did not at any time blow from the east quarter. I think we are therefore justified in inferring the following generalizations.

1. In a majority of those cases in which an area of low barometer passes over New England attended by the usual system of circulating winds at the surface stations, this system of circulating winds does not extend to the height of 6,000 feet.

2. When the depression of the barometer is unusually great, this system of circulating winds extends to the greatest height.

3. When during the progress of an area of low pressure, a system of circulating winds reaches to the summit of Mt. Washington, the change of wind to the east quarter usually begins at the surface stations eleven hours sooner than it does on the summit of that mountain; and the change back from the east to the west quarter usually begins at the base of the mountain five hours sooner than on the summit.

Abnormal storm paths.

In the hope of obtaining some information respecting the causes which determine the movement of areas of low barometer from place to place, I selected from the published volumes of the Signal Service observations those cases in which storm paths deviated most from their average course, and the results are shown in the two following tables, one containing those cases in which the direction of storm paths was most northerly, and the other containing those cases in which their direction was most southerly. Table II contains various particulars respecting eight storms whose course was nearly from south to north. Column 1st shows the number of the storm; column 2d shows the number of the observation; column 3d the date of the observation; and column 4th the station at which the observed height of the barometer was least. This station was not generally at the center of the low area, but is presumed to have been not far distant from the center; column 5th shows the height of the barometer at the station named in column 4th; column 6th shows how much the barometer at the given date was below its mean height for that month as deduced from the observations of six years; column 7th shows how much the thermometer on the north side of the low area was depressed below its mean height for the hour of observation; column 8th shows how much the thermometer on the south side of the low area rose above its mean height for the hour of observation; column 9th shows the average humidity of the winds on the north side of the low area; column 10th the average humidity on the south side of the low area; column 11th shows the direction 'and velocity of the highest wind reported at any station on the north or west side of the low area; column 12th the direction and velocity of the highest wind reported at any station on the south or east side of the low area; column 13th shows the total rain-fall at all the stations east of the Rocky Mountains during the preceding eight hours; column 14th shows the total rain-fall at all the stations included within the same low area; and column 15th shows the direction of the center of the rain area from the center of low pressure for a time preceding the date of observation by four hours. When the center of low pressure is near the boundary of the United States it is generally impossible to determine from the observations where is the center of the rain area; and in such cases a blank is left in column 14th. When the center of the rain area coincided sensibly with the center of low pressure the syllable *cent.* is inserted. Table III contains similar particulars respecting six storms whose course was nearly from north to south. The last case in each of the tables was taken from the International series of observations in which the observations are given for only one hour of each day, and the rain-fall is the amount reported for the preceding twenty-four hours.

On comparing these two tables we find important differences in several particulars. In each case of Table II, with the exception of the last, the barometer became more depressed as the storm moved northward, and at the last observation of each case the average depression of the barometer below the mean was 0·26 inch greater than at the first observation. In each case of Table III the depression of the barometer increased for 16 hours or more, and then decreased, with the exception perhaps of the last case where the storm is only followed to Dodge City. In the other cases, the average depression of the barometer at the last observation was somewhat less than at the first

TABLE II.—*Storms Moving Northward.*

No. of Storm.	No. of Obs.	Date.	Lowest Barometer.		Below mean.	Temp.		Hum.		Highest Wind.				Rain Fall.		
						N. wind.	S. wind.	N. wind.	S. wind.	North'ly.		South'ly.		Total.	In Low.	Which side.
		1872. Dec.		in.	in.	— °	+ °							in.	in.	
I.	1	19.1	Indianola.	29·70	·40	25	13	77	98	N.	12	S.	14	3·01	2·94	N.E.
	2	19.2	Nashville.	·79	·40	21	16	81	87	N.W.	17	S.	24	5·77	5·77	N.E.
	3	19.3	Louisville.	·62	·53	15	11	84	88	N.	20	S.E.	20	6·70	6·70	N.E.
	4	20.1	Buffalo.	·43	·56	19	12	80	89	N.W.	16	S.E.	24	14·37	14·37	N.E.
	5	20.2	Montreal.	·50	·58	12	8	79	88	N.W.	24	S.E.	18	5·28	5·28	
		1873. Jan.														
II.	6	1.3	Indianola.	·43	·70	8	12	81	87	N.E.	8	S.E.	16	0·64	0·54	N.N.E.
	7	2.1	St. Louis.	·53	·64	4	15	89	88	N.E.	11	S.E.	15	6·29	6·15	N.N.E.
	8	2.2	Milwaukee.	·23	·85	1	16	87	90	N.W.	29	S.E.	24	9·12	9·12	Cent.
	9	2.3	Milwaukee.	·07	1·01	2	11	82	90	N.W.	20	S.	20	6·28	6·28	
	10	3.1	Marquette.	·09	·98	3	19	82	90	N.W.	35	S.	20	7·84	7·37	
		Apr.														
III.	11	7.2	Indianola.	·66	·35	17	5	68	71	N.	25	S.	19	3·20	3·20	N.N.E.
	12	7.3	Memphis.	·68	·32	10	21	82	75	N.	28	S.E.	16	3·45	3·45	N.N.E.
	13	8.1	Cairo.	·64	·35	21	14	75	80	N.	34	S.E.	20	8·70	8·69	N.E.
	14	8.2	Louisville.	·52	·45	18	19	89	80	N.E.	32	S.	35	8·54	8·54	N.E.
	15	8.3	Chicago.	·54	·42	7	18	83	82	N.	26	E.	33	4·48	4·48	Cent.
	16	9.1	Escanaba.	·42	·55	17	15	85	85	N.	16	S.E.	32	3·75	3·75	
	17	9.2	Marquette.	·42	·58	12	14	67	83	N.W.	23	S.	32	3·98	3·98	
		Oct.														
IV.	18	19.2	Charleston.	·64	·45	4	3	66	91	N.W.	12	E.	13	6·84	6·84	N.
	19	19.3	Norfolk.	·52	·58	10	8	77	94	N.	16	S.E.	24	9·82	9·82	N.
	20	20.1	Cape May.	·45	·62	19	16	82	95	N.	28	S.E.	32	17·65	17·65	N.
	21	20.2	Phila'phia.	·26	·82	14	11	56	93	N.	36	E.	42	12·27	12·27	N.
	22	20.3	Pittsburgh.	·38	·63	15	13	78	95	N.	28	S.E.	32	9·86	9·86	N.
	23	21.1	Erie.	·28	·69	13	11	78	83	N.	32	S.	24	5·90	5·90	N.W.
	24	21.2	Alpena.	·36	·58	14	9	65	78	N.	20	S.	28	3·01	3·01	N.W.
		1874. Jan.														
V.	25	5.3	Jacks'ville.	·95	·25	8	12	81	91	N.E.	20	E.	24	3·05	3·04	
	26	6.1	Montgom'y.	·90	·32	8	17	86	95	N.E.	18	E.	24	8·82	8·78	N.N.E.
	27	6.2	Augusta.	·74	·46	4	11	79	89	N.	16	S.	16	12·48	12·48	N.
	28	6.3	Augusta.	·61	·59	0	16	83	89	N.	24	S.E.	24	8·35	8·35	N.
	29	7.1	Lynchburg.	·57	·61	1	26	82	95	N.E	18	S.E.	24	11·81	11·81	N.N.E.
	30	7.2	Pittsburg.	·46	·67	7	22	88	93	N.W.	18	S.E.	18	9·48	9·48	N.E.
	31	7.3	Cleveland.	·54	·56	1	26	85	92	N.	12	S.	12	6·27	6·27	E.N.E.
	32	8.1	Oswego.	·46	·60	3	33	81	97	N.W.	12	S.	20	5·65	5·65	E.N.E.
	33	8.2	Ottawa.	·31	·67	2	29	72	87	N.W.	18	S.	20	1·68	1·68	
		Mar.														
VI.	34	6.1	Ft. Gibson.	·40	·56	17	10	86	85	N.	12	S.E.	24	10·93	10·93	N.E.
	35	6.2	Keokuk.	·23	·78	9	16	74	83	N.	30	S.	29	5·16	5·06	E.N.E.
	36	6.3	Dubuque.	·16	·86	5	21	77	87	N.W.	35	S.E.	27	5·76	5·22	N.E.
	37	7.1	Milwaukee.	·17	·86	13	3	7	89	N.W.	32	S.	25	8·82	8·77	
	38	7.2	Alpena.	·24	·76	11	9	75	84	N.W.	28	E.	20	3·92	2·32	
		1877. Feb.														
VII.	39	28.2	Indianola.	·90	·23	15	8	52	82	N.	12	E.	13	1·12	1·11	N.
	40	28.3	Galveston.	·88	·22	6	7	49	93	N.E.	12	E.	12	2·31	2·31	N.
		Mar.														
	41	1.1	Shreveport.	·73	·33	6	4	68	95	N.W.	12	S.E.	14	4·15	4·01	Cent.
	42	1.2	Memphis.	·56	·52	8	2	69	93	N.E.	10	S.	20	9·43	9·43	N.E.
	43	1.3	Cairo.	·42	·65	4	9	85	88	N.E.	16	S.	28	5·17	5·17	E.
	44	2.1	Chicago.	·17	·85	4	16	84	87	N.W.	16	S.E.	24	13·62	11·45	N.E.
	45	2.2	Saugeen.	·12	·87	3	12	78	90	N.W.	24	S.	40	18·52	18·52	
		Dec.														
VIII.	46	21.1	Concho.	·56	·44	7	14	82	89	N.	12	S.E.	24	12·00	12·00	N.E.
	47	22.1	Dodge City.	·37	·43	7	35	88	93	N.W.	32	S.E.	24	11·34	11·34	E.N.E.
	48	23.1	Bismark.	·55	·40	8	37	82	93	W.	12	S.E.	20	12·43	12·43	E.N.E.
Means.						9.5	14·7	78	88		20.8		23·0		6·89	

Table III.—*Storms Moving Southward.*

No. of Storm.	No. of Obs.	Date.	Lowest Barometer.		Below mean.	Temp.		Hum.		Highest Wind.		Rain Fall.		
						N. wind.	S. wind.	N. wind.	S. wind.	North'ly.	South'ly.	Total.	In Low.	Which side.
		1877. Jan.		in.	in.	— °	+ °					in.	in.	
I.	1	3.3	Pembina.	29·91	·20		2		70	N.W. 16	S. 14	0·82	0·00	
	2	4.1	Ft. Sully.	·83	·27	3	5	82	79	N.W. 28	S. 16	0·99	0·22	
	3	4.2	Ft. Sully.	·67	·43	0	5	74	77	N.W. 28	S. 13	1·11	0·63	E.
	4	4.3	Omaha.	·80	·33	3	9	86	72	N. 25	S. 10	0·54	0·48	E.
	5	5.1	Ft. Gibson.	·80	·36	2	3	86	78	N.W. 34	S. 7	0·49	0·30	S.S.E.
	6	5.2	N. Orleans.	·90	·28	6	0	76	68	N.W. 20		0·96	0·90	S.E.
II.	7	9.3	Virginia C.	·46	·19		7		80		S. 18	0·70	0·59	E.
	8	10.1	Virginia C.	·31	·34	14	12	75	81		S.E. 24	0·80	0·72	E.S.E.
	9	10.2	N. Platte.	·07	·78	20	17	73	81	N.E. 24	S.E. 18	0·97	0·77	E.
	10	10.3	N. Platte.	·03	·82	22	10	76	76	N.E. 24	S.E. 12	1·24	0·41	Cent.
	11	11.1	Ft. Gibson.	·64	·52	35	22	83	81	N.W. 25	S.E. 12	2·03	1·74	E.N.E.
	12	11.2	Denison.	·76	·45	29	19	77	74	N.E. 32	S. 20	6·88	0·20	N.
	13	11.3	Corsicana.	·95	·25	35	20	71	84	N.E. 34	S. 12	2·98	0·76	N.
	14	12.1	Indianola.	30·05	·09	21	24	82	91	N. 20	S. 10	1·16	0·99	N.N.E.
		Feb.												
III.	15	17.3	Ft. Garry.	29·79	·39		20		77		S. 12	0·34	0·00	
	16	18.1	B'kenridge.	·73	·41		18	78	78	N.W. 30	S. 16	0·42	0·00	
	17	18.2	Milwaukee.	·55	·52	3	16	63	64	N.W. 26	S.E. 20	1·55	0·99	E.S.E
	18	18.3	Toledo.	·58	·50	6	14	75	66	N. 26	S. 15	1·02	0·98	E.N.E.
	19	19.1	Pittsburgh.	·59	·50	11	5	76	62	N.E. 24	S. 4	0·42	0·27	N.E.
	20	19.2	Norfolk.	·63	·47	11		64		N.W. 20	S.W. 14	0·46	0·39	N.E.
	21	19.3	Wilm'gton.	·76	·37	7		63		N. 32		0·53	0·43	
	22	20.1	Savannah.	·88	·28	6		72		N.E. 30		1·42	0·39	
IV.	23	20.3	Pembina.	·64	·49		26		77		S. 10	0·03	0·00	
	24	21.1	B'kenridge.	·54	·60		27		75		S. 12	0·00	0·00	
	25	21.2	Duluth.	·35	·72		43	63		N.W. 45	S. 25	0·15	0·15	
	26	21.3	St. Paul.	·38	·70		23	76		N.W. 27	S. 21	0·19	0·19	
	27	22.1	LaCrosse.	·46	·65		28	79	63	N.W. 30	S. 21	0·18	0·18	
	28	22.2	Davenport.	·53	·60	0	21	61	56	N. 30	S. 13	0·79	0·78	S.
	29	22.3	St. Louis.	·58	·53	4	20	71	57	N. 24	S. 8	1·80	1·80	S.S.E.
		Mar.												
V.	30	21.3	N. Platte.	·19	·45	15	24	78	58	W. 28	S. 14	9·44	0·00	
	31	22.1	Omaha.	·46	·55	19	21	76	63	N.W. 20	S.E. 14	8·59	0·13	
	32	22.2	Dodge City.	·07	·56	13	21	58	59	N. 44	S. 26	5·21	0·27	N.E.
	33	22.3	Ft. Gibson.	·66	·30	19	19	80	57	N.E. 40	S.E. 16	1·30	0·19	N.W.
	34	23.1	Ft. Gibson.	·73	·23	19	17	79	73	N. 24	S.E. 8	3·81	1·11	N.
	35	23.2	Corsicana.	·67	·33	14	15	62	45	N.E. 30	S.E. 17	4·81	1·31	N.
	36	23.3	Indianola.	·83	·25	10	15	73	69	N. 22	S. 11	3·70	2·93	N.
		1878. Feb.												
VI.	37	18.1	Virginia C.	·44	·20	6	18		75		S. 16	4·82	0·20	
	38	19.1	B'kenridge.	·38	·76	8	21	71	72	N. 12	S.E. 17	1·56	0·04	
	39	20.1	Dodge City.	·06	·74	0	28	86	76	N.W. 19	S. 18	3·46	2·89	E.
Means.						12.0	17·1	74	71	27·1	14·8		0·57	

observation, and less than half of what it was at an intermediate date. In table II the average temperature of the winds on the north side of the low area was 9·5 degrees below the mean for that time and place; and the average temperature of the winds on the south side of the low area was 14·7 degrees above the mean for that time and place. In table III the average temperature of the winds on the north side of the low area was 12 degrees below the mean, and on the south side was 17 degrees above the mean. The blanks in columns seven and eight of table III result from the center of least pressure being near the boundary of the United States, so that the signal service stations do not furnish the required data. In both tables the average humidity of the north winds was nearly the same, but the humidity of the south winds was very much the greatest in table II. In table II the average velocity of the south winds was ten per cent greater than that of the north winds. In table III the average velocity of the north winds was about double that of the south winds. In table II the average rain-fall in eight hours within the low areas was 6·89 inches; in table III the average rain-fall was 0·57 inch, and in a majority of the cases in this table the average rain-fall in eight hours was only 0·14 inch.

The most remarkable circumstance which characterizes these two classes of storms is the difference in the amount of rain-fall. In the cases shown in table II the rain-fall was enormously great, and this appears to be the general characteristic of those storms which originate near the Gulf of Mexico. In my seventh paper, I gave a list of all the cases contained in the volumes of the Signal Service observations which had then been published, showing a total rain-fall of eight inches in eight hours at all of the stations. More than two-thirds of all these storms originated on or near the Gulf of Mexico, and a majority of the remaining cases occurred in summer. One reason why these storms are attended by a great fall of rain appears to be that the south wind is charged with a large amount of vapor from a warm sea. From table II it appears that this south wind is warm, moist, and pushes northward with great force.

The principal object which I had in view in preparing these tables was to discover, if possible, the reason why these storms pursued so unusual a path. The average course of the eight storms in table II was only 20 degrees east of north. One of them moved almost exactly north, and another deviated sensibly to the west of north. Can any reason be assigned for this unusual course? I have endeavored to determine whether there was any connection between the course of the storm and the rain-fall which accompanied it. Plate I of my 7th Paper shows the curves of equal rain-fall for the eight hours preceding

7^h 35^m, Oct. 20, 1873, and corresponds to No. 20, table II of the present Article. At that date the center of low pressure was moving almost directly towards the center of the rain-area. Plate I accompanying the present Paper, shows the isobars for Oct. 21.1, 1873, and the dotted line shows the area over which the rain-fall for the preceding eight hours amounted to at least one-fifth of an inch. The rain-fall at Cleveland was ·75 inch; Alpena ·58 inch; Rochester ·49 inch, and Saugeen ·49 inch. It will be perceived that during these eight hours the storm center had been moving almost exactly towards the center of gravity of this rain-area. There was also a rain-area extending along the New England coast from Boston to Eastport which did not appear to exert any appreciable influence upon the progress of the storm. I have made a similar comparison for each date in table II and find that in each case the storm center was moving nearly towards the center of the rain-area. In more than half of the cases the storm appeared to be moving exactly towards the center of the rain-area. In four of the cases the rain center appeared to be a little westward of the storm path, and in twelve cases it appeared to be a little eastward, but in only two or three cases did it deviate as much as 45° from the direction in which the storm center was moving. This coincidence seems to favor the conclusion that in a great storm the condensation of the aqueous vapor is an efficient cause which controls the movement of the winds.

Table III shows results very different from table II. In six of these cases no rain was reported at any station within the area of low pressure during the preceding eight hours; in 23 of the cases the total rain-fall during the preceding eight hours at all the stations within the low area was less than half an inch; and in only five of the cases did the total rain-fall in eight hours exceed one inch, and in each of these five cases there appears to have been a special reason for the greater rain-fall. In No. 11 the rain center was about 600 miles northeast of the center of low pressure, and the succeeding observation shows that there was another low center in Canada which mainly controlled the movement of the winds throughout this rain-area. In No. 29 the character of storm No. IV had already changed, and the subsequent course of the storm was nearly east. In Nos. 34, 35 and 36 the greater rain-fall is partly explained by the proximity of the low center to the Gulf of Mexico. In No. 39 the rain-fall is given for a period of 24 hours. Thus we see that an area of low pressure may be formed with very little rain, and apparently with none at all. Moreover in these cases the storm center did not generally follow the rain area but moved away from it. Plate II accompanying this paper shows the isobars for Jan. 4, 1877, at 4^h 35^m P. M., indicating a low center near Ft. Sully.

The rain-fall reported for the preceding 8 hours was as follows: 1. Milwaukee, 0·14 inch; Marquette, 0·10; Grand Haven, 0·08; Escanaba, 0·05; Port Stanley, 0·02; Detroit, 0·01; and Toledo, 0·01, amounting together to 0·41 inch. Around the first four of these places I have drawn a dotted line, which is designed to represent the area over which the rain-fall was at least 0·05 inch. 2. A rain-fall of 0·09 inch was reported at Bismark and of 0·05 at Ft. Sully. I have also drawn around these places a dotted line representing the area of 0·05 inch rain-fall. 3. A rain-fall of 0·08 inch was reported at North Platte. Thus we see that the principal rain-fall was about 600 miles east of the low center, and the low center traveled southward apparently uninfluenced by this rain-fall. There was a smaller rain area which was nearly concentric with the area of low pressure, and there was a very slight fall of rain on the south side of the low center. I have made a similar comparison for each of the dates of observation, and find the following results: In seven of these cases the principal rain center was about 350 miles north of the center of the low pressure; in four of the cases it was on the northeast side, and at a distance of about 500 miles; in eight of the cases it was on the east side, distant about 600 miles; in one case it was on the northwest side; in one case it was on the southeast side; and in only three cases was the center of the rain-area nearly south of the center of low pressure, viz: Nos. 5, 28 and 29. In the last case the storm, instead of following the rain towards the south, immediately changed its course and moved off towards the east. Thus, out of thirty-nine cases we find only one case in which the storm seemed to follow the rain-area, but in half of the cases the storm traveled almost directly away from the rain-area, and in nearly all of the remaining cases the course of the storm was nearly at right angles to the direction of the rain-area. These facts seem to show that in these cases the rain-fall exerted no appreciable influence upon the course of the storm, and therefore no appreciable influence upon the fall of the barometer. This conclusion is confirmed by the observation of the clouds. In all the cases given in table III, the average cloudiness on the south side of the low area was less than one-half; and in several cases the sky was *entirely cloudless* at every station on the south side of the low area. This was true for Nos. 15, 16, 17, 23, 24, 30, 31 and 32.

This evidence appears to me to show that heavy and extensive precipitation does not invariably precede the first formation of depression areas and accompany their expansion, as has been claimed. These depression areas increased in intensity when the rain-fall was nearly zero, and while the sky on the south side was not generally overcast with clouds, but in several cases was almost entirely clear. In the United States, depression areas do not generally begin with extensive precipitation, but the rain-fall is a concomitant after the system of circulating winds has become pretty well established. The depression of the barometer is the result of a system of circulating winds, and the most frequent cause producing such a system appears to be two or more areas of high pressure at a considerable distance, (frequently 1,400 miles) from each other. Differences of temperature and of humidity are also important agents in producing and sustaining such a system of winds. When a system of circulating winds has been formed over a large extent of country, there almost invariably results a fall of rain; and if the rain-fall is abundant, and extends over a large area, it becomes a very important agent in modifying the direction and force of the winds.

The principal question still remains undecided, why did the storms in table II pursue a course so nearly from south to north, and those in table III, a course nearly from north to south? The average course of storm paths appears to be determined mainly by the average system of circulation of the atmosphere near the earth's surface, and occasional departures of storm paths from this average track appear to be mainly due to causes which render the general movement of the atmosphere at such times different from the average movement. In table II it is seen that the average velocity of the winds on the south side of the storm's center was somewhat greater than on the north side. This seems to indicate that at these times a wind from the south or southeast pressed towards the storm-area with unusual force. This wind extended to a height greater than 6,000 feet, as is shown by the observations on Mt. Washington whenever a storm center came into the neighborhood of that station. The following observations show the direction and force of the wind on that mountain during the progress of storm No. IV. Oct. 20.1, wind S.E. 75 miles; Oct. 20.2, wind S.E. 78 miles; Oct. 20.3, wind S. E. 50 miles; Oct. 21.1, wind S. E. 55 miles; Oct. 21.2, wind S.E. 38 miles. The observations also show that this south current extended to the height of the upper clouds. This is seen from Plate I, where the arrows indicate (*not* the direction of the surface winds), but the direction of the upper clouds, according to the reports of the Signal Service observations for Oct. 21.1, 1873. These arrows conform in a remarkable degree to the direction of the surface winds, and seem to indicate that the system of circulating winds which prevailed at the surface of the earth, extended to a height greater than 6,000 feet into the region of the upper clouds; a height which is very uncertain and difficult to estimate. The only important exception to the rule here stated is the observation at Davenport, which appears suspicious, since at the afternoon observation of the same day, the upper clouds were reported from the northwest. Generally throughout the eastern half of these low areas the lower clouds were dense and unbroken, so that there was no opportunity to obtain observations of the direction of the upper clouds, but in several cases observations were made which indicated a circulation of the winds at the height of the upper clouds similar to that described for Oct. 21.1. This is seen in the observations of Nos. 8, 24, 29, 30, 35 and 36.

In table III the velocity of the wind on the north side of the low areas was nearly double that on the south side, and this northerly wind extended to a considerable height, as is shown by the observations on Pike's Peak. The following observations show the direction and force of the wind on that mountain during the progress of storm No. I. Jan. 3.3, wind north 30 miles; Jan. 4.1, wind north 42 miles; Jan. 4.2, wind north 32 miles; Jan. 4.3, wind north 38 miles; Jan. 5.1, wind northeast 20 miles; Jan. 5.2, wind north 36 miles. This northerly current extended to the height of the upper clouds. This is seen from Plate II, where the arrows indicate the direction of the upper clouds according to the reports of the Signal Service observers for Jan. 4.2, 1877. These arrows indicate a movement of the upper clouds from the west or northwest over nearly the whole of the United States from the Pacific Ocean to the Atlantic; and throughout the western half of this region the movement was mainly from the northwest. At no station were the upper clouds reported as moving from the southeast, east or northeast, and at only one station were they reported from the south. At the thirty-nine dates enumerated in table III, there were only five cases in which the upper clouds were reported from the east at any station which could be regarded as included within the system of circulating winds here considered; there were five cases in which the clouds were reported from the southeast, and thirty-one cases in which the clouds were reported as moving from the south, and about half of these cases occurred Feb. 22d, when storm No. IV was losing its previous character and preparing to change its course from south to east. These facts seem to indicate that the surface winds which prevailed on the south and east sides of the low areas enumerated in table III, were not only dry and feeble, but extended to a less height than the southerly winds which attended the storms enumerated in table II.

These facts seem to indicate that at the time of the observations in table II, there was an unusually strong current from the south or southeast, which reached to a height of over 10,000 feet, and swept over a considerable portion of the United States;

while at the time of the observations in table III, there was an unusually strong current from the north or northwest, which also reached to a height of more than 10,000 feet, and swept over the United States from the Pacific Ocean to the Atlantic.

The cases enumerated in table III are remarkable on account of the long continuance of the movement of storm centers from north to south, but the published volumes of the Signal Service observations show many other cases in which storms pursued a similar course for twenty-four hours or more.

In preparing the materials for this article, I have been assisted by Mr. Henry A. Hazen, a graduate of Dartmouth College of the class of 1871.

Art. II.—*Silurian Formation in Central Virginia;* by J. L. Campbell, Washington and Lee University.

Limits.—What is known as the "Great Valley of Virginia" occupies a belt of country extending entirely across the State from the Tennessee line on the southwest to the Potomac on the northeast—including Jefferson and part of Berkeley County, now a portion of West Virginia. It has mountain boundaries throughout its whole extent. On its southeastern margin it is separated from what is called "Piedmont Virginia," by the Blue Ridge and its southwest prolongations, Poplar-Camp and Iron Mountains. On the northwest side we find a somewhat irregular line of broken ridges bearing different names at different points. Through several of the southwest valley counties it is called "Walker's Mountain." In Botetourt, Rockbridge and Augusta, it is called "North Mountain," while through the remainder of the distance to the Potomac it is called "Little North Mountain." The length of the Valley, from the Tennessee line to the Potomac, is about three hundred and thirty miles. Near its southwest extremity, in Washington County, it is about twelve or fifteen miles wide, and becoming gradually wider it extends towards the northeast. We find it in Rockbridge and Augusta varying in breadth from twenty to twenty-five miles. Its total area, embracing the contiguous mountain slopes on each side, is not much short of 6,000 square miles.

Its Topography.—With the exception of a limited belt occupied by the Massanutton range in its northeast parts, and some strips covered by outliers of North and Walker's Mountains, this extensive zone has for its surface one continuous outcropping of the Lower Silurian rocks. Before examining into the geological features of this interesting region, it will be well to take a bird's-eye view of its topography. (1.) It lies between two elevated mountain ranges—the Blue Ridge on the southeast rising to heights ranging generally between 2000 and 4000 feet above tide-level; and the North Mountain range on the northwest, almost equally high at many points. (2.) The axial line of the Blue Ridge (which consists chiefly of Archæan rocks) has but few gaps through which streams of water can pass. Not a single outlet of any considerable size is found for the waters of the valley through this ridge anywhere between Harper's Ferry on the Potomac and Balcony Falls on the James—a distance of one hundred and fifty miles. The only other water-gaps are the one through which the Roanoke (afterwards the Staunton) River passes towards the southeast, and the narrow, rugged ravines by which the waters of New River (Kanawha) and some of its tributaries run down from the Plateau formed by the bifurcation of the Blue Ridge towards its southwest extremity. But along the northwest side of the axial ridge, throughout the greater part of its extent, we find a large number of short broken ridges and irregular peaks, forming sometimes double, and often triple, lines nearly parallel with the main mountain, and indicating by their position and structure that they were once continuous ridges that have since been fractured and cut into deep gorges, through which small streams of water now run down into the limestone valley below. These broken ridges consist of Primordial rocks. The mountains on the northwest are far less regular and continuous than the main Blue Ridge, and are traversed by numerous water-gaps. Here the Upper Silurian (Medina) Sandstones constitute the material of which most of the ridges are constructed, and the heavy beds are frequently arched or folded, and cut through by ravines of considerable extent and grandeur, like that through which New River makes its way towards the Ohio, or the beautiful arch at Clifton Forge, or the grand "Goshen Pass" between the Chesapeake and Ohio Railroad and Lexington.

(3.) Those who have not visited this section of the State must not imagine that the "valley" is one vast continuous plain like some of the western prairies. It is a land of "hill and dale, of water-brooks and fountains of water." Its limestone and cherty ridges are frequently of such dimensions that in many parts of the world they would be called "mountains;" and where they are cut by the bold and rapid streams that abound here, they present many steep and naked cliffs, sometimes more than two hundred feet in height above the water. Such natural sections present features of great interest to the geologist; and afford important aid in ascertaining the real structure and relative position of the several sub-divisions of this, the most remote age of paleozoic history.

(4.) Any good map of Virginia will show that this valley is not single, whether viewed lengthwise or crosswise. From a few miles southwest of Winchester to a point nearly opposite Harrisonburg, it is divided into two subordinate valleys, by the Massanutton Mountains—a long belt of ridges of Upper Silurian and Devonian rocks that withstood the denuding agencies that uncovered so many hundreds of square miles of the Lower Silurian limestones. Less extensive ridges also interrupt the continuity on the northwest side; and some of them, like the House Mountain,* across which the accompanying section passes, present striking examples of mountains *left* in isolated positions by the sweeping away of the once adjacent rocky masses through the powerful denuding agencies of water and ice. That such agencies have operated in this region on an extensive scale will be considered more fully hereafter.

The cross divisions of the valley are marked by the water-sheds that determine its drainage. Southwest of Wythe County we find the waters carried off by the Holston into the Tennessee River. Wythe, Pulaski and part of Montgomery, are drained by New River, which runs down from the Blue Ridge plateau, crosses towards the northwest and makes its way to the Ohio. Thus we have "New River Valley." A small portion of Montgomery and nearly all of Roanoke County, are drained by the Roanoke River—one of the three rivers that have cut water-gaps through the Blue Ridge in a southeasterly direction. Next to this "Roanoke Valley" comes the upper "James River Valley," occupied by Botetourt and Rockbridge. Extending from the water-shed (crossing near the line between Rockbridge and Augusta) to the Potomac, we find the extensive "Shenandoah Valley."

(5.) *Elevations.*—At Harper's Ferry, where the Potomac leaves the Great Valley, the height above tide-level is only about two hundred and forty feet; but when we reach the head waters of the Shenandoah, we have arrived at a water-shed having an average height of nearly 1800 feet. Then, in passing on to the south corner of Rockbridge, we come to the "pass" of the James, at Balcony Falls, having an elevation of about 700 feet. The Roanoke Valley has about the same average elevation as that of the James Valley, 1200 feet; but on rising to the margin of New River Valley, near Christiansburg, in Montgomery County, we are about 2000 feet high; and on the southwest margin, at Mount Airy—the summit of the A. M. & O. Railroad—2600 feet. Many points on the Blue Ridge are not higher than this highest part of the great limestone valley. At the Tennessee line the height is less than 1700 feet.

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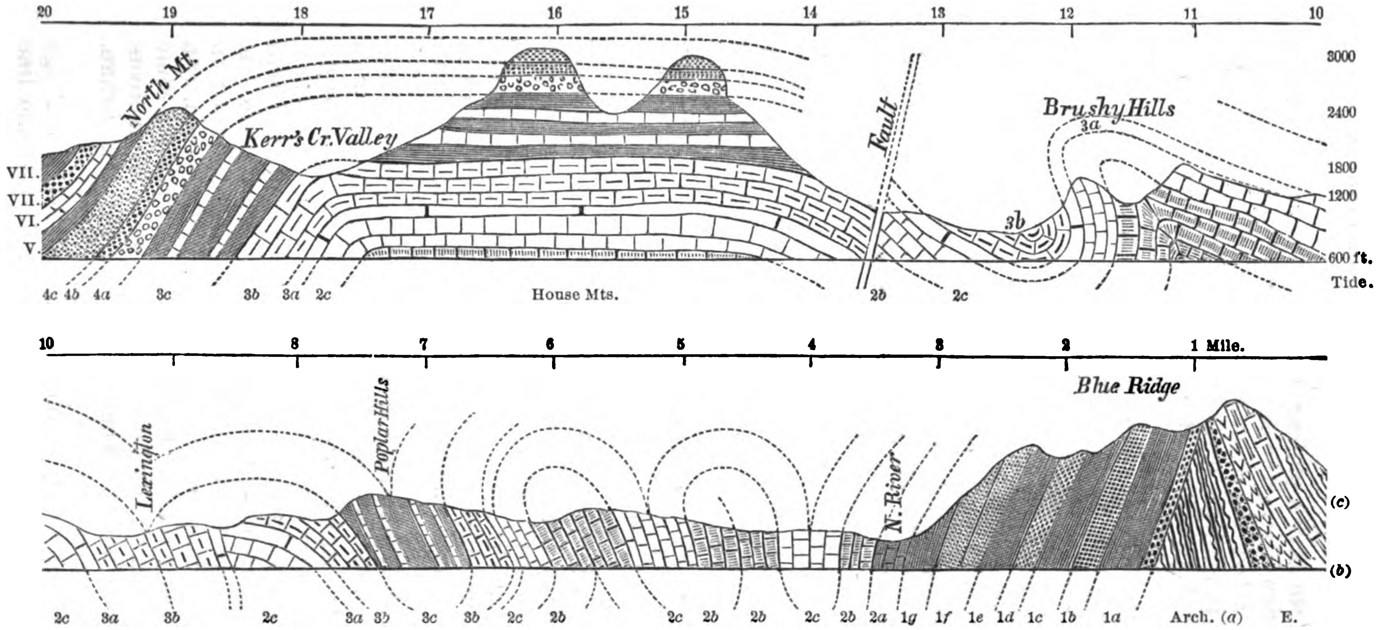
* This is often spoken of as if it were a single mountain—and so it appears to be as seen from Lexington—while, in reality, there are two short parallel ridges nearly a mile apart, cut off abruptly at both ends.



Section of Silurian Formation, Rockbridge Co., Va.—From S. E. to N. W. 20 Miles.

Description of Section.—1. The leading divisions of strata are denoted by the numbers 1, 2, 3, 4; V, VI, VII, VIII, corresponding with the Pennsylvania series (Rogers). 2. Sub-divisions are indicated by letters attached to the numbers, as 1*a*, 1*b*, 2*a*, etc. 3. On the right-hand end below (the proper place to begin the examination), the Archaean rocks are marked, "Arch. (*a*), (*b*), (*c*);" while an eruptive mass protruding near the crest of the Blue Ridge is marked, E. 4. The beds of sandstone are *dotted*,—coarsely when more or less conglomerate; beds of shale have closely *ruled* lines; limestone strata are *blocked*, some having *longitudinal* and some *cross* rulings, to distinguish *epochs*. 5. The feldspathic rocks east of Blue Ridge have double longitudinal lines. 6. Heights above tide level are indicated on the right of the upper division of the section.

Here, then, we have a plateau, rather than a valley, with an average elevation above the sea of about 1200 or 1300 feet. This is much above the average elevation of the Mississippi Valley. It is in reality a part of the great belt of uplift that constitutes the Appalachian Range, but erosive agencies have stripped it of the greater part of its mountain-making masses. The Blue Ridge, which now forms its southeast border, was once the shore-line of the great primal ocean that covered the Mississippi Valley (including "Appalachia") during the remote ages of geological history.

At present the streams of water in the valley tend towards the southeast margin all the way from the Potomac to Salem, in Roanoke County. This is most strikingly the case in the basins drained by the Roanoke and the James Rivers, thus indicating less elevation on that side than on the other. I think we shall learn hereafter that this is most probably the result of difference in the amount of denudation on the two sides.

This brief summary of the most conspicuous physical features of the Great Valley and its surroundings is deemed sufficient to give the reader a tolerably distinct, though very general view of the *present* surface formed by the outcropping of the most extensive exposure of Lower Silurian rocks in Virginia. There are other less extensive exposures of the same rocks forming subordinate limestone valleys, but they must be left out of our present discussion.

Geology.—My purpose is to give in the first place a section extending from the Blue Ridge to the North Mountain, embracing some of the Archæan rocks at one extremity, and of the Devonian at the other. The discussion of this, with its divisions and sub-divisions, and some leading peculiarities of each, will, I think, illustrate the geology of this middle part of the State in a manner, and to an extent, not hitherto attempted by any one.

I am indebted to the partial survey of Virginia, made under the direction of the venerable and distinguished geologist, Professor W. B. Rogers, for guidance and aid in my own investigations and for many of the facts contained in this communication. The line of section here given has been carefully explored and re-explored throughout its whole extent, several times. It crosses a portion of the valley not heretofore represented in section, so far as I know; and while it may be regarded, to a certain extent, as typical of this region of the State for some miles on each side of its line, it presents some peculiarities worthy of special notice. These will be discussed in future. For the present a general description must suffice.

The southeast extremity is on the slope of the Blue Ridge beyond Robinson's Gap, and extends one mile past the line between Rockbridge and Amherst Counties; while the northwest reaches about a mile beyond the crest of the North Mountain to the valley of the Rockbridge Alum Springs, where it cuts the Devonian shales from which the waters of those springs flow. A subordinate ridge of Medina sandstones, however, rises in the valley between the end of the section and the Springs.

The first general division includes the metamorphic and eruptive rocks of the main Blue Ridge. The other general divisions are those adopted by Professor Rogers in his survey of the State (1836–41). Only Nos. I to VII are included. The sub-divisions into which each of these is here divided are my own, and may be regarded as representative (with local modifications), not only of the limestones of the Great Valley, but also of the shales and sandstones of the bordering mountains and outlying ridges on both sides. They are marked, *a*, *b*, *c*, etc., in ascending order, and will be found to correspond with many of the subdivisions given by Professor Dana in his Manual of Geology (ed. 1875).

There is no natural section or gap through the metamorphic and eruptive rocks at this point on the Blue Ridge, but the outcrop is quite distinct, except that of a mass of syenite (E) protruded among the stratified rocks. The crest of the ridge is marked by a heavy bed of syenitic gneiss (or stratified syenite), (*b*) which might readily be taken for an igneous rock—so greatly has it been metamorphosed. This, with the thinner beds of like composition, and the interstratified slates (*c*) all dip steeply to the S.E.—or rather S.S.E. Beneath the mass of syenite we find first gneissoid rocks with considerable quantities of epidote; and under these, slates and sandstones, all dipping conformably with those above. These are *a* of the metamorphic group on the section.

Against the upturned edges of these metamorphic strata we find the lowest of the Primordial beds, resting *unconformably*, and dipping in the opposite direction. Here begins No. I of Professor Rogers's divisions. It might be subdivided into very many alternations of sandstones and shales, but I have preferred to limit the number to *seven*, that are quite constant in their general features for many miles along the N.W. face of the range. At the grand natural section at Balcony Falls, where the James River passes through the mountain, about fifteen miles S.W. of my line, there is a very interesting exposure of all the divisions here given—similar in relative position, similar in lithological and fossil characters, and having the same general dip.

No. I.—The group, No. I, *a*, as a general rule, has a layer of feldspathic and siliceous conglomerate near the bottom, then dark shales alternating with sandstones more or less conglomerate. The shales, however, predominate. Next comes a bed (*b*) of very hard sandstone—quartzite; the upper and lower layers of which are more brittle than the main mass lying between them. This is succeeded by a much thicker mass of brown, purple and yellow shales (*c*), with thin beds of brittle sandstones. This mass is extensively disintegrated at the James River pass on both sides, where its thickness is about 550 feet, including a considerable bed of sandstone which at that point seems to separate it into two somewhat distinct divisions. But at Robinson's Gap, and other places, this bed of interstratified sandstone either disappears or becomes very thin. The bed (*d*) is very constant, very hard, and has a jointed structure so deeply marked and so extensive, that the cleavage planes thus developed have sometimes been mistaken for planes of stratification dipping S.E. The division (*e*) consists of shales of much lighter color than those found lower in the series. Some of the beds are decidedly kaolin in character, with numerous scales of mica disseminated through them. Up to this point we find only very faint indications of fossil remains of either plant or animal. A few scolithus borings (in *b* and *d*) are found, but they are rare, in comparison with what are found in (*f*). This (*f*) is the "typical sandstone" of the range, and constitutes the frame-work of what was once a continuous ridge, but is now crossed by numerous gorges, which have divided it into many short ridges and irregular knobs and peaks. It is a hard sandstone of white and light gray color, and jointed structure; and along this and other parts of its range it "exhibts vague, fucoidal and zoophytic impressions on the surface of bedding, together with innumerable markings at right angles to the stratification, penetrating in straight lines to great depths in the rock, and from their frequency and parallelism determining its cleavage in nearly parallel planes. These markings are of a flattened [many of them] cylindrical form, from $\frac{1}{8}$th to $\frac{1}{16}$th of an inch broad, giving the surface of the fractured rock a ribbed appearance, and resembling perforations made in sand which have been subsequently filled up, without destroying the original impression." Such is Professor W. B. Rogers's description of the characters given to this heavy bed of rock by the *Scolithus linearis.* These fossils are so numerous that I recently counted at Balcony Falls about 150 of their extremities projecting on one square foot of surface. This may very properly be called the "Scolithus bed" of this Primordial formation. The thinner beds at the top and bottom disintegrate rapidly. Between this and the first limestone of the valley is a thick mass of ferruginous shales generally much disintegrated and covered with the debris of sandstone from the adjacent ridges just described. This is (*g*) on the section. It sometimes rises to a considerable height on the slope of the "scolithus bed," especially where the dip is low; and in a few cases, as at Irish Creek, I have found it reaching the crest of the ridge. It is one of the richest repositories of iron ore in Virginia—especially brown hematite—and has valuable beds of manganese, one of which, near Waynesboro', in Augusta county, is at present extensively worked. The ores of the Shenandoah Iron Works of Page county are obtained from this bed of shale. Although it abounds in iron ores, yet it has the peculiar feature of containing a layer of clay so white as to be called "chalk" by the people of the region.

This brings us to the border of the limestones of the valley, and the plane of division between No. I and No. II. Thus we have passed over the Primordial Period. If it has here representatives of both the Acadian and Potsdam epochs (which I doubt) the lowest shales and sandstones must represent the former, and the upper shales and sandstones the latter. For the present, at least, I shall regard the whole as belonging to the Potsdam. The total thickness varies considerably as we ascend the ridges. This is especially conspicuous in the beds of shale, and causes such a decided variation in the dip of the sandstones as to make them present the appearance in many places of segments of broken arches; the dip varying as it does here and at Balcony Falls from 65° at the base to 30° near the upper margin, or outcrop of the beds. This peculiarity has been caused either by an original thinning out of the beds towards their margin before they were upheaved, or by a squeezing out of a portion of their material by the resistance and pressure of the more unyielding beds of sandstone above and below, at the period of upheaval.

The *thrust*, which was doubtless from the Blue Ridge towards the valley, seems to have been more powerful near the base than it was near the summit. Hence the steeper dip below, which has become reversed in the limestones for several miles from the foot of the mountain.

No. II.—The first natúral subdivision (*a*) of the valley limestones may with propriety be called the "Hydraulic Formation," inasmuch as it abounds in hydraulic limestones throughout its whole length. It includes, however, several layers of very siliceous and argillaceous limestones separated from one another by beds of brown, bluish and purple shales, and some soft sandstones. The best bed of hydraulic stone is near the bottom of this division, and where it has been quarried for many years, near Balcony Falls, is only about twelve to fifteen feet thick, and dips steeply to the N.W. Where our section crosses the strata of *a* they are nearly vertical. From this point to the Brushy Hills beyond Lexington, the strata (with one or two local and very limited exceptions), all dip towards the Blue Ridge; and, upon a superficial view of the case, might be supposed to extend beneath it. But examinations of the relative position of the sandstones and limestones at other points in the valley, together with lithological and fossil peculiarities that prove the more recent origin of the limestones, lead to the conclusion that they are *geologically* above the sandstones and shales already described. The several repetitions of the subdivisions of No. II, between the Poplar Hills and North River can be accounted for only upon the hypothesis of plications in the strata caused by pressure on the one side and resistance on the other. We conclude, therefore, that the hydraulic beds (*a*), as originally deposited on the ancient sea-bottom, underlie those of *b*, while these again were overlaid by the beds of *c*. Only occasional fucoid plants, and brachiopod mollusks have been seen in *a*. It seems to be the equivalent of the Calciferous Epoch of New York (3 *a*, Dana).

No. II *b*, embraces a series of heavy beds of dark blue limestones, with some dark brown and yellow shales intervening. A large proportion of the limestone is magnesian (dolomitic), and some beds hydraulic. The oxide of iron abounding in this formation, gives a dark brown color to the soils produced by its disintegration. These are among the best and most durable soils of the valley. The next and upper division (No. II *c*), is characterized lithologically, (1) by having the greater part composed of light blue and bluish-drab colored limestones, with yellow shales interstratified, especially among the lower beds; (2) by one and sometimes two beds of coarse, brown, friable sandstone between layers of light-colored limestones, and (3) by a remarkable bed of *chert* near its upper limit. This hard, flinty, durable rock has so far resisted the force of disintegrating agencies, as to be left as a covering on the faces of many of the limestone hills throughout a large extent of the Great Valley. This chert bed varies in thickness from one to ten feet within the range of a few miles; but it and the brown sandstone lower down serve as well defined land-marks for this whole formation. The brown sandstone has preserved imperfect impressions of several species of brachiopod shells, while in the chert bed are found in some localities large numbers of silicified shells of gasteropod and cephalopod mollusks. This division (*c*) by disintegration yields light clay and sandy or pebbly soils, according to the varying characters of the outcropping strata. These soils are only moderately productive—some of them very poor. Local deposits of limonite ore in this formation have been mined in past years to supply some of the iron furnaces in Augusta county.

The lithological and paleontological characters of this group of rocks, as well as its position seem to identify it with the Chazy Epoch (3 *c*, Dana).

The dotted lines on the section give an ideal representation of the foldings and inversions to which these rocks were subjected when turned up from their original bedding. There was not, of course, the regularity and symmetry in the foldings that these lines indicate, for there are along the line many evidences of local warpings, fractures, dislocations, etc., that could not appear on such a section. Several trap-dykes are found protruded through the rocks of No. II, in Augusta and Rockingham counties, but none, so far as I know, in Rockbridge. The Natural Bridge, from which this county takes its name, is in *b*—being a portion of one of its upper strata spanning a cañon or gorge, cut through its lower beds to a depth of more than 200 feet.*

No. III.—In some respects this group of rocks differs so widely here from its condition in Augusta and Rockingham counties, where Professor W. B. Rogers adopted it as typical in his earlier Reports, that I feel confident that he then regarded some of the heavy, but quite irregular beds of limestone in the Lexington basin as a part of No. II, but I am equally confident that he would, upon a more detailed examination, class them as Trenton Limestones—base of III.

The lower bed (*a*) of this group is peculiar, as far as I have yet observed, to Rockbridge and adjacent portions of Botetourt and Augusta counties. It has all the appearance of an old coral reef very much disintegrated, stratified, and subsequently solidified by the infiltration of carbonate of lime which has given the mass a crystalline texture, and converted it into a gray limestone, very compact and admirably adapted for building purposes. The bed has well defined horizons both below, where it is separated from the chert of No. II *c*, by one or two thin layers of light blue limestone; and above, where it is covered with a layer that is shaly in some places and in others very hard, and full of white veins of calcite and dolomite. The upper and lower portions of this coralline bed are quite full of shells as well as fragments of coral; the middle portion is more purely coralline, more compact, and better adapted to the architectural purposes to which it is extensively applied; and to the manufacture of lime. The most easterly outcrop in this neighborhood is on Hoffman's Run, about one mile S.E. of the town, where the total thickness is about sixty (60) feet. It seems to run out somewhere beneath the synclinal fold that forms the Poplar Hills, but appears again on Buffalo Creek, six miles to the S.W. N.W. of Lexington the outcrop of this bed is finely displayed along some parts of the base of Brushy Hills, and especially on the North River, a mile above the town bridge, where it forms a nearly vertical cliff, exposing its entire thickness, which at this point is about 150 feet. This thickness is preserved in the synclinal between Brushy Hills and House Mountain, and also at other points where it appears below (*b*) the thicker mass of Trenton Limestone.

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* I incline to the belief that this gorge was originally a *crevice* in the strata, and subsequently enlarged by erosion—not the result of erosion alone; the arch having escaped fracture when the crevice was produced.

No. III, *b*, crops out extensively on both sides of Poplar Hills, forms the whole of the synclinal over which Lexington stands,* and is the foundation rock of the House Mountains, around the base of which it may be seen cropping out on all sides. The general position here is horizontal, or nearly so, with some local curves. Northwest of Kerr's Creek valley it disappears beneath the North Mountain.

The general structure of *b* differs very widely from all the lower limestones—the beds here, except some of the lowest, being thin layers of argillaceous limestones, with interstratified shales. Near the base of *b*, especially along its S.E. portion, underlying the Poplar Hills, we find a bed of very compact blue limestone irregularly bedded and very full of infiltrated veins; but, as we ascend, the rocks become more and more argillaceous, with the beds of shale becoming more numerous; and finally, as may be seen on House Mountain, after passing upward through a thickness of about 650 feet, the shale becomes predominant, but still contains some thin beds of limestone remarkable for the profusion of fossil shells, crinoids and coral found in them. There is no well-defined horizon here, between what is represented on the section as *b* and *c*, but the former seems in general characters to be the equivalent of the Trenton limestone, and the latter of the Cincinnati (Hudson) shales. It is about 750 feet thick.

Remark.—I have not seen any outcrop of the division, *a*, of No. III in Augusta county northeast of Staunton, nor have I seen it at all in Rockingham. If its equivalent appears in that part of the valley, it is under quite different lithological and fossil peculiarities. I might say almost as much in regard to *b;* for limestone beds form a very inconspicuous part of III, from Staunton (or rather a point S.E. of that place) to a point in Rockingham county, where it passes under IV in the Massanutton range of mountains.

"FAULT."—This seems to be the proper place for directing attention to the "Fault," the line of which passes in front (S.E.) of the House Mountain. It is easily traced for several miles both ways from one line of section. The lower and older rocks of No. II are found (in their own normal order) overlying the newer of No. III *b*, which dip beneath them. At a number of points between Kerr's Creek and Collier's Creek, two considerable streams that run out from the N. Mountain at the opposite extremities of the House Mountain ridges, this dipping of the newer under the older rocks may be seen along a line of very considerable regularity.

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* This synclinal is really *double*—having a line of uplift running through it, but the scale of the section would not admit its insertion. There are also some local irregularities here.

Our general description has now extended to the horizon between the Lower and Upper Silurian.

No. IV, the equivalent of the Medina group, is composed of very durable sandstones that are the chief mountain-making rocks along the northwest margin of the valley, and throughout a belt of twenty or twenty-five miles wide, parallel with it. It may be represented under three subdivisions. The lower one of which (*a*), is a very hard, light gray, sometimes white, sandstone, distinctly conglomerate in many places, and so durable as to present long lines of precipices where the strata crop out on the faces of the mountains. The middle member (*b*) of this group is a dark brownish purple sandstone with beds of interstratified shales of the same color. Shells in the sandstones, and fucoids in the shales, are conspicuous features of this division. A third member (*c*) is much lighter in color than *b*, but darker than *a*. Some of the harder layers have a pinkish hue, while the softer and more brittle, especially near the top, where they border on No. V, are brown and yellowish brown in color. While this group, as it appears on the two ridges of House Mountain, rests upon a nearly horizontal base, in the North Mountain its position is changed to that of a steep northwest dip.

The general pressure that acted from the Blue Ridge side of the valley towards the northwest, seems to have lifted the House Mountain ridges somewhat above what was the original level of the surrounding region, and, at the same time, to have broken off and pushed back the edges that now form the crest of North Mountain. But while the section represents the general result, it will be found on examination, that there are a number of local and limited irregularities in the form of contortions and fractures that could not be exhibited on a scale representing so much space within so short a limit. So, also, it has here, apparently, a greater degree of symmetry on the surface, than the denuding forces to which it has been subjected, have given it. But in this regard, also, the irregularities are too numerous and limited to find a place on the section.

The strata of this group all thin off as they extend farther towards the interior basin of the coal regions. They also vary much in thickness where they crop out along the margin of the valley. What now caps House Mountain is about three hundred and sixty feet thick, while, at the highest point, it may have lost one hundred feet or more of its original height. On the Warm Springs Mountain, in Bath County, twenty miles farther towards the great Appalachian coal basin, the thickness is very perceptibly less. At Panther Gap, two or three miles west of Goshen, where the Chesapeake and Ohio Railroad passes through Mill Mountain, a very complete section of No. IV is displayed as a folded and inverted anticlinal—inverted towards the northwest so that the higher strata of V, VI and VII, seem to underlie IV.

No. V is in most places, in this part of the Appalachians, a bed of shales and brittle, shaly sandstones. In the upper part the shales predominate and have some thin bands of limestone. Valuable iron ores, some of them highly fossiliferous, abound in this formation. The development of this group is not extensive where our line of section cuts it. This seems to be the only representative we have here of the Clinton and Niagara epochs (*5b*, and *5c*, Dana).

No. VI is not actually visible where the section passes, but its outcrops on both sides of the same valley, at points not very remote, seem to justify the hypothesis that it actually exists at this point though concealed from view by the debris of sandstone and clay from the adjacent mountain. In this part of the Appalachian range it consists almost entirely of limestones that are remarkable for the profusion of fossil coral, shells and encrinites found in them. The stone is pure enough in some of its beds to make good lime, and firm enough to make good building material for houses, railroad masonry, etc. In the prolongation of the same mountain valley, in which our section terminates, this formation is largely developed along the line of the Chesapeake and Ohio Railroad, between Goshen and Buffalo Gap. At Craigsville, nine miles northeast of Goshen, it affords an extensive quarry of beautiful encrinal marble. It is the Helderberg Limestone. (7 Dana.)

No. VII is a singular bed of brownish and greenish-gray sandstone of coarse texture, easily broken, and in many places disintegrates readily under the weather. In other localities it is more durable, forms rather low flat arches, and when cut through by streams presents precipitous exposures. It is said to have valuable deposits of iron ore at several points in Virginia. Great numbers of fossil brachiopods, especially *Spirifer arenosus* and *Rensselæria ovoides*, are found in it everywhere.

This is a remarkably well defined formation, readily distinguished by its lithological peculiarities and its fossil remains. It is cut by the Chesapeake and Ohio Railroad at several places between Buffalo Gap and Goshen. On the turnpike leading from Millboro to the Warm Springs, about three miles from the station at which the stage coaches leave the railroad, this formation may be seen as an anticlinal arch, spanning the lower limestone of VI, in which the famous "Blowing Cave" of Bath County is situated. Here the Calfpasture River has cut through a ridge and given a natural section along the base of which the stage-road passes, and where the Oriskany and Helderberg formations are well exposed, and, together with the Blowing Cave, present points of considerable scientific interest. Here, also, the meeting of the Oriskany, the upper member of the Silurian, with the Marcellus (?) shales, at the base of the Devonian, may be distinctly observed on both sides of the ridge.

The following table exhibits a comparison of the subdivisions in this portion of the Virginia valley, with the periods and epochs in Professor Dana's Manual:

Silurian rocks of the Great Valley of Virginia with their subdivisions, compared with equivalent epochs of Dana's Manual, p. 142.

Ages	Periods.		Epochs.	Rogers' Series.		Virginia Valley Subdivisions.
Upper Silurian.	Oriskany.	8	Oriskany,	No. VII.		Spirifer Sandstone.
	L. Helderberg.	7	L. Helderberg.	No. VI.		Encrinal Limestone.
	Salina.	6	Salina.	No. V.	*c*	Calcareous Shales.
	Niagara.	5*c*	Niagara.		*b*	Ferriferous Shales.
		5*b*	Clinton.		*a*	Shaly Sandstones.
				No. IV.	*c*	Upper Sand-rock.
		5*a*	Medina.		*b*	Purple Shale and Sandstone.
					a	Conglomerate.
Lower Silurian.	Trenton.	4*c*	Hudson Riv.	No. III.	*c*	House Mt. Shales.
		4*b*	Utica.			
		4*a*	Trenton.		*b*	Lexington Limestones.
					a	Coraline Limestones.
	Canadian.	3*c*	Chazy.	No. II.	*c*	Cherty Limestones.
		3*b*	Quebec.		*b*	Dolomitic Limestones.
		3*a*	Calciferous.		*a*	Hydraulic Limestones.
				No. I.	*g*	Iron-bearing Shales.
	Primordial or Cambrian.	2*b*	Potsdam.		*f*	Scolithus Sandstones.
					e	Kaolin Shales.
					d	Middle Sandstones.
		5*a*	Acadian.		*c*	Middle Shales.
					b	Lower Sandstones.
					a	Lower Shales.
Azoic.	Archæan.		Archæan.	Metamorphic.	*c*	Slates and Syenite Gneiss.
					b	Bedded Syenite.
					a	Lower Slates.
				Igneous.	*E*	Eruptive Syenite.

ART. III.—*On a new form of Spectrometer, and on the distribution of the intensity of Light in the Spectrum;* by JOHN WILLIAM DRAPER, M.D., President of the Faculty of Science in the University of New York.

I HAVE invented a spectrometer which I think will open a new and interesting field to those who are engaged in spectrum analysis.

The ordinary spectroscope is occupied with the frequency of ether-vibrations or wave lengths. This, which I am about to describe, has a different function. It deals with the intensity or brilliancy of light.

It depends on the well known optical principle that a light becomes invisible when it is in presence of another light about sixty-four times more brilliant.

In some researches, published by me in 1847, on the production of light by heat or the incandescence of bodies, I used this method as a photometer, and became sensible of its value. The memoir in which those experiments are related may be found in my recently published "Scientific Memoirs," page 23.

Having also published in 1872 a memoir on the distribution of heat in the prismatic spectrum, and shown that the cause of its increasing intensity from the more to the less refrangible regions is due to the compression of the colored spaces that correspondingly takes place, owing to the action of the prism itself, but having failed to obtain satisfactory measures in the case of the diffraction spectrum, in which such compression or condensation does not occur, I was led to reflect whether better success might not be secured by attempting to measure the relative intensity or distribution of the light.

Admitting what is commonly received as true, that the yellow is the brightest of the colored spectrum spaces, and that the luminous intensity diminishes from that in both directions, above and below, I supposed that if such a spectrum was brought in presence of an extraneous light, the illuminating power of which could be varied at pleasure, that after the red and the orange on one side, and the green, blue, indigo and violet, on the other, had been extinguished, the yellow would still remain in the midst of the surrounding illumination. On making the experiment it turned out differently.

For the sake of clearness of description I will call this extraneous light, from the function it has to discharge, *the extinguishing light.*

There are many different plans by which the principle above indicated may be carried into practical effect. Several of these I have tried, and have found the following a convenient one.

Remove from the common three-tubed spectroscope its scale tube, and place against the aperture into which it was screwed a piece of glass, ground on both sides. In front of this arrange an ordinary gas light, attached to a flexible tube, so that its distance from the ground glass may be varied at pleasure. On looking through the telescope tube, the field of view will be uniformly illuminated, this being the use of the ground glass. The brilliancy of the field depends on the distance of the gas light, according to the ordinary photometric law.

1st. *Case of the prismatic or dispersion spectrum.*—If the extinguishing light be for the moment put out, and in the proper place before the slit tube the *luminous* flame of the Bunsen burner that accompanies the apparatus be arranged, on looking through the telescope a spectrum of that luminous flame will of course be seen. The slit itself should be very narrow, so that the spectrum may not be too bright.

Now let the extinguishing flame be placed before the ground glass, and a spectrum is seen in the midst of a field of light, the brilliancy of which can be varied at pleasure. If the extinguishing flame be at a suitable distance, the whole spectrum may be discerned. As that distance is shortened, first the violet, and then the other more refrangible colors in their descending order disappear, and at length in the steadily increasing effulgence the red alone remains. The yellow never stands out conspicuously as might have been expected.

This is scarcely consistent with the assertion that the yellow is the brightest of the rays. The red is plainly perceptible long after the yellow has gone. There is a greenish tint emitted by gas-light that disappears a little previously to the extinction of the red.

From these observations I think that the luminous intensity of the colored spaces has a relation to the compression or condensation that the prism is impressing upon them. It may be that, properly considered, the intrinsic intensity of the light is the same for all. In this we must always bear in mind the physiological peculiarities of the eye.

The foregoing statement is perhaps sufficiently explicit to enable any one to verify the facts. I may, however, mention some improvements in the apparatus, which experience has led me to adopt.

The intensity of the extinguishing light may be insufficient to obliterate the spectrum, even though the slit be closely narrowed. How then may the intensity of the spectrum be diminished, and that of the extinguishing light be simultaneously increased? I accomplished this by depositing on that face of the prism which acts as a reflector an *excessively* thin film of silver. This, though it was transparent to the transmitted rays increased very greatly by its metallic reflection the extinguishing ones. I could not see any difference between the spectrum of the light that had come through this film and that before the face was silvered, but the reflected light was incomparably more brilliant. The complete obliteration of the entire spectrum presented now no difficulty.

Nothing need be said about collateral contrivances, which would suggest themselves to any one: A strip of wood a metre long, and bearing divisions served to keep the extinguishing lamp in the proper direction as regards the ground glass, and indicated its distance. I may add, however, that satisfactory observations can be made very conveniently by keeping the extinguishing flame at a constant distance, and varying its intensity by opening or closing its stop-cock. This avoids the trouble arising from moving the flame. In one instrument I caused an index attached to the head of the stop-cock to move over a graduated scale, and so ascertained how much it was opened. This, though permitting of pleasant working, had not the exactness of the method of distances.

Such are the results obtained from the prismatic dispersion of gas-light. I completed this part of the investigation by an examination of sunlight. For this purpose I resorted to the foregoing principle, introducing a beam of sunlight, reflected from a heliostat through a slit. The spectrum of this was thrown upon a paper screen, so placed that by opening or closing an adjacent window-shutter the light of the sky in greater or less quantity could fall upon the paper, and act as an extinguisher. When the shutter was fully opened the spectrum was quite obliterated, and on gradually closing it so as to diminish the extinguishing light, the red region first came into view, the other colors following in the order of their refrangibility, the extreme violet appearing last. On reversing the movement of the shutter the colors disappeared in the reverse order, the red disappearing last.

At the moment when the red was approaching extinction there always existed on its more refrangible side a gleam of grayish-green light. It was in the position of that greenish gleam which appeared as I have described when gas-light was examined. Its color recalled to my mind the faint greenish-gray light I had seen when a strip of platinum is ignited by a feeble electric current, as described in my memoir of 1847, above referred to.

Subsequently I constructed a camera having two apertures in its front. Through one of them, by a suitable arrangement of a heliostat, slit, direct-vision prism, and convex lens, a solar spectrum was formed on the ground glass. Through the second aperture, which was about an inch square, covered with a glass ground on both faces, an extinguishing beam of sunlight passed. This ground glass served to disseminate the extinguishing light uniformly over the spectrum. I could regulate the power of this light by varying the size of the aperture through which it came by means of a slide.

It is needless to give details of the results obtained by this instrument. They were identical with those described in the foregoing paragraphs.

It might be supposed that the irrationality of dispersion of different prisms would influence the results perceptibly. Accordingly, I tried prisms of different kinds of glass and other transparent substances, but could not find that this was the case. In all, the extinction began in the violet and ended in the red.

Nor did there seem to be any difference when the effect was viewed by different eyes. To persons, irrespective of age or the condition of their sight, the extinction took place in the same manner. I had not an opportunity of examination in a case of color-blindness.

2d. *Case of the Grating or Diffraction Spectrum.*—If the cause of the increasing intensity of light in the prismatic spectrum from the more to the less refrangible region be the compression exercised by the prism on the colored spaces, increasing as the refrangibility is less, we ought not to find any such peculiarity in the diffraction spectrum. In this the colored spaces are arranged uniformly and equably in the order of their wavelengths. An extinguishing light ought to obliterate them all at the same moment.

Having modified the common spectroscope by taking away its dark box so that the slit tube and telescope tube could be set in any required angular position, I put in the place of its prism a glass grating inclined at forty-five degrees to rays coming in through the slit. The ruled side of the grating was presented to the slit. Now when the extinguishing flame was properly placed before the ground glass, the plane side of the grating reflected its light down the telescope tube. In this, as in the former case, the spectrum was seen in the midst of a field of light, the intensity of which could be varied by varying the distance of the extinguishing flame, or by varying the opening of its stop-cock. This light needs no reënforcement by increasing the reflecting power of the back face of the grating, these spectra being much more feeble than that given by a prism, and the unassisted light being quite able to extinguish them.

As the glass grating I was using gave its two series of spectra of unequal brightness, I selected the most brilliant, and in it used the spectrum of the first order. I saw, not without pleasure, that as the force of the extinguishing illumination increased, all the colored spaces yielded apparently in an equal manner, and disappeared at the same moment. Sometimes, however, there seemed to be a very slight difference in favor of the red. On diminishing the illumination all the colors came into view apparently at the same time. This spectrum gives a better opportunity than the prismatic for observations on the yellow space, which by being uncompressed, exposes a wider surface to view. This yellow space showed no superiority in resisting extinction over the other colors.

But as gas-light, compared with sunlight, is deficient in the more refrangible rays, I repeated the examination of the latter, as I had previously done for the prismatic spectrum, modifying the apparatus so as to use a grating in the place of the prism. The observations in this case of sun-light were quite as satisfactory as those in which gas-light had been used.

General conclusions.—1st. In the prismatic spectrum the luminous intensity increases from the more to the less refrangible spaces, its maximum being not in the yellow but in the red. This is due to the action of the prism, which narrows, and as it were, condenses the colored spaces more and more as we pass toward the red, increasing the intensity of the light as it does that of the heat.

2d. In the grating, or diffraction spectrum, the luminous intensity is equal in all the visible regions, all the colors being simultaneously obliterated by an extinguishing light.

It must, however, be borne in mind that these conclusions should be taken in connection with the physiological action of the eye. Owing in part to the imperfect transparency of its media, and partly to the inability of its nervous mechanism to transmit waves of certain frequency to the brain, the spectrum does not begin and end sharply, as to a perfect eye a perfect spectrum ought to do.

There are, hence, two causes which must not be overlooked in these observations. 1st. The physiological peculiarity of the eye, which gives to each end of the spectrum the aspect of gradually fading away. 2d. In the case of solar-light the absorptive action of the atmosphere, which is chiefly exerted on the more refrangible rays.

I think, bearing in mind the correlation of light and heat, both being corresponding manifestations of the same vibratory movement in the ether, that these results substantiate those I published in 1872, on the distribution of heat in the spectrum; and that as the different colored spaces are equally luminous, so they are equally warm.

I have made some attempts to compare with each other the luminous intensity of the bright lines in various spectra, especially those emitted by a strontium flame, but not being able to continue these researches at present, I have postponed them to a more favorable opportunity.

University of New York, May 5th, 1879.

ART. IV.—*On the Extinct Volcanoes about Lake Mono, and their relation to the Glacial Drift;* by JOSEPH LECONTE.

[Read before the National Academy of Sciences, April 16, 1879.]

IN 1870, and again in 1872, in company with a party of students and graduates of the University of California, I visited the Mono region. But on both occasions my attention being specially directed to the study of the ancient glaciers, I examined the volcanoes only somewhat cursorily. In 1875 with a similar party I again visited the same region, and this time remained longer and examined more carefully, though on account of an unfortunate accident, not so long or so carefully as I desired. I have put off from year to year the publication of the results of my observations in the hope of again visiting the region and settling some doubtful points which still remained. There seems now, however, little likelihood that I shall ever be able to carry out my intention, for other questions of still greater interest have in the meantime engaged my attention. I will therefore no longer withhold my imperfect observations, hoping that they will be corrected and extended by others.

General description of the region.—Eastern slope of the Sierra.—As already explained in previous papers,* the general form of the Sierra is that of a great wave ready to break on its eastern side. It rises from the San Joaquin plains by a gentle slope which extends 50 to 60 miles, reaches a crest 13,000 feet high, then plunges downward by a slope so steep that it reaches the plains of Mono 6000 ft. above sea level, in five or six miles. In glacial times, long, complicated glaciers with many tributaries occupied the western slope, while on the east, comparatively short simple glaciers came down in parallel streams and ran far out on the level plain and into the swollen waters of Lake Mono, which, then nearly 700 feet above its present level and far beyond its present limits, washed against the base of the Sierra itself. There can be no doubt that these glaciers formed icebergs which floated on the surface of the great inland sea and dropped débris over its bottom.

The Plains.—Surrounding Lake Mono and sloping imperceptibly to its surface, is a nearly level desert plain, covered with volcanic sand interspersed with fragments of pumice and obsidian, and overgrown with sage-brush (*Artemisia tridentata*). It is undoubtedly an old lake bottom, subsequently covered with volcanic ashes. The dreary prospect of this desert is relieved by the magnificent irregular Sierra wall trenched with deep cañons; by long parallel moraine ridges stretching like arms from the mouth of each cañon, five or six miles out on the level plain, and bounding the pathways of ancient glaciers; by a fine cluster of recently extinct volcanic cones fifteen to twenty in number and very perfect in shape, and finally by the bright waves of the lake studded with picturesque islands.

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* This Journal, III, v, 325, 1873; x, 126, 1875; xvi, 95, 1878.

Moraines.—Some of the parallel moraines which form so conspicuous a feature of the scene, especially those of Bloody cañon, I have already described.* From the top of any of the higher volcanic cones, many others may be seen stretching out upon the plain. These moraine ridges average 300 to 400 feet in height and five to six miles in length, but some of them, especially those at the head of Rush Creek, are much higher. The view of glacial moraines here presented is incomparably the finest I have ever seen.

Lake.—Lake Mono is a fine sheet 14 by 10 miles in extent. There being no outlet the waters are of course saline. It is essentially a strong solution of sodium carbonate, with smaller proportions of lime carbonate, common salt and borax. To the taste it is simply a concentrated solution of carbonate of soda. While camping on its margin we found its powerful detergent property very useful in clothes-washing. The mineral contents are probably partly the concentrated leachings from the volcanic rocks which cover the whole plains—the alkaline silicates of these rocks being changed into alkaline carbonates by carbonic acid of the air—and partly contributed by springs which issue in many places from the bottom and around the margins of the Lake, and were probably more numerous and active in former times. In any case, the lake waters are now but the concentrated residues of a much larger body of water, as plainly shown by the terraces to be presently described. During the process of concentration the less soluble lime carbonate has been deposited in strange irregular masses of calcareous tufa. These curious fungoid and coralloid masses, some of them six to ten feet in height, stand up thickly on the level shores and in the shallow marginal waters of the lake. At a distance they look like the half-submerged stumps of a forest of gigantic trees. This carbonate of lime deposit is evidently identical with the thinolite deposit described by King† as occurring in such immense quantities about the residual lakes of the Nevada basin farther north, and which as he shows is a pseudomorph of carbonate of lime after Gay-Lussite. The conditions under which the deposit took place about Mono are probably, however, slightly different from those in Nevada, and I believe throw much light on the general question of thinolite deposits. It deserves careful study and I hope to take it up in a subsequent paper. Farther east, near Columbus, Nevada, in the region of the dried-up lakes left at the extreme southern extension of King's ancient lake *Lahontan*, occur remarkable deposits of ulexite (soda-lime borate) which also deserve separate study.

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* This Journal, III, v, 325. † Geol. Exploration 40th Parallel, i, 508, and seq.

Terraces.—I have already mentioned the terraces about Lake Mono. Several of these are very distinct and traceable all around the lake. But they are seen in greatest number and most distinctly on the west side, where the lake approaches the Sierra and the hills rise abruptly from the lake-level. Five or six may here be counted, rising one above the other like level benches, the highest being, according to Whitney, 680 ft. high. These terraces are undoubtedly the marks of old lake levels, and show not only a former greater depth but also a much greater extent of the lake waters. The highest level traced about the lake would reach the moraines at the foot of the Sierra, extend beyond the plains on every side, and enclose an area many times greater than the present lake-area. There can be no doubt therefore that the great glaciers of that time ran into the lake and formed icebergs.

Islands.—Near the center of the lake there is a group of volcanic islands in direct line with the groups of volcanic cones on the plains to the south and doubtless a continuation of the same line of volcanic activity. The largest of these islands is about 2½ miles long, a mile wide and about 300 feet high. It is composed mainly of extremely fine, whitish material, beautifully and very finely laminated, the differently colored laminæ being very distinct and scarcely thicker than cardboard. This material is spoken of by Whitney* as volcanic ashes. Under the microscope it proves to be composed wholly of *diatom shells* with only an occasional grain of sharp sand. There is no doubt therefore that it was deposited very slowly in calm waters, in the middle of the lake and beyond the reach of detritus. The stratification is mostly horizontal; only in two or three places where the deeper strata are exposed on the cliffs by the action of waves, I observed a slight dip, and in one place a gentle but distinct *anticline*, showing a quiet upheaval of the whole mass, as I think, by volcanic forces. In the highest parts of the island, the soft, horizontally-laminated earth is sculptured by erosion into sharp pinnacles and turrets like bad-land structure on a small scale. On the eastern portion of the island a considerable area of black basaltic rock is exposed, but this is no where more than 50 feet high. Where the diatomaceous earth comes in contact with the basalt, the former always overlies the latter in undisturbed horizontal layers. I conclude therefore that the basalt preceded the formation of the diatomaceous mud, was once entirely covered by the latter, and was subsequently exposed by erosion.

* Geol. Survey of California, i, 453.

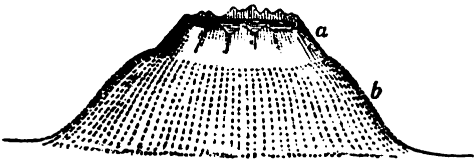
Steam and boiling water issue in many places in this rocky portion of the island and in the shallow water in the vicinity. I observed also in the earthy portion crater-like depressions, containing a little saline water, which were probably produced by similar fumarole action now extinct. According to Whitney (p. 453) two distinct true craters occur in the basalt on the northeast portion of the island; but these I did not see.

The other and much smaller islands I did not have time to visit, but according to Whitney, they are wholly basaltic, and the largest of them is 300 feet high, and is a well-defined volcanic cone.

The general conclusion, at which I arrived from my examination of the largest island, was that the basaltic portion was first formed at the bottom of the lake, or else subsequently submerged; then the diatomaceous mud was deposited, covering it up completely; then the fine mud-bottom was raised into an anticline and exposed as an island by the fall of the lake level, and finally erosion sculptured the whole, and in part exposed the underlying basalt.

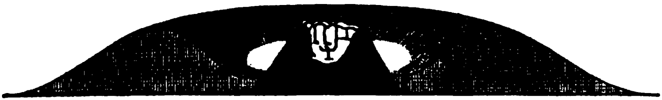
Volcanoes on the Plains.—We have already alluded to a conspicuous group of volcanic cones situated on the level plain south of the lake. These are twenty or thirty in number, extending in a line from near the margin of the lake to a distance of ten to fifteen miles, and vary in height from 200 to 2,700 feet above the plain. Partly from the recency of their extinction, and partly from the small rainfall of the region, they are, some of them, as perfect in form as if they were still in action. A good general view of these is given by Whitney in his account of this region. The typical form of the more perfect is shown in fig. 1, which, though intended only as a diagram, is yet a tolerably correct outline of the highest and most perfect. The upper part *a* is a light-colored pumiceous lava, and the lower part *b* is covered with sand of the same.

1.



In many cases I observed a very perfect cone-and-rampart structure, such as is known to be produced by great eruptions, followed by smaller ones; or perhaps in some cases by an engulfment of the crater into the base of the cone. The most perfect example of this kind is found in a small and easily accessible cone, not far from the lake. Fig. 2 is an ideal section and half perspective view of this cone. It consists of a low sand cone about 200 feet high, with a perfect circular crater one and a half to two miles in circumference, from the center of which rises a trachytic cone and crater of much smaller dimensions, to about the same height. From the shattered condition of the inner cone, Mr. Muir suggested to me the possibility of the engulfment of the upper rocky portion into the lower sandy portion of a once much higher cone. But, in many other cases observed, this explanation is evidently untenable; for in some cases we found several small cones surrounded by one rampart. Such could only be formed by successive eruptions.

2.



The material erupted by these volcanoes is in some cases basalt, but by far the largest amount consists of feldspathic slags, pumice and pumiceous sands and ashes. The whole plains of Mono are covered to a depth of many feet with a nearly white volcanic sand, mingled with fragments of pumice and obsidian.

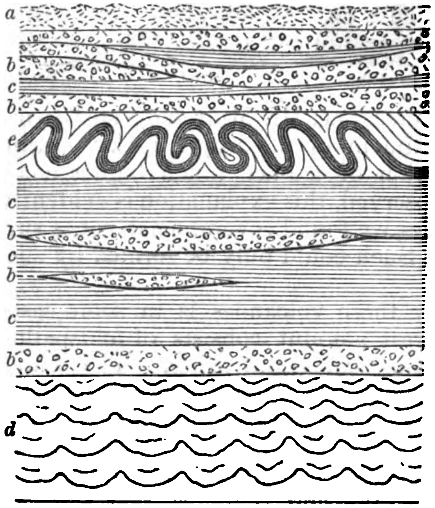
Age of the Mono Volcanoes.—There is abundant evidence that these volcanoes have been active, and therefore that they assumed their present forms since the epoch of great separate glaciers in this region (Champlain). Whether they also existed and erupted previously is perhaps doubtful though probable. The evidences of the extreme recency of the eruptions, which determined their present forms, are as follows:

1. We have already shown the splendid scale on which glaciers were once developed in this region. We have already given reasons for thinking that they ran down the Sierra, out on the plains and into the lake, and produced icebergs there. It is impossible that the volcanic cones, if they then existed, could have escaped the powerful action of ice, and the equally powerful action of other meteoric agencies, so characteristic of that epoch, which must have entirely destroyed their form. The remarkable perfection of their conical forms and of their craters is therefore strongly presumptive if not demonstrative, of the fact of their eruption since the disappearance of the glaciers.

2. All the streams, which run from the Sierra into Lake Mono, cut into the level plains 100 to 150 feet deep. Fine sections of the materials of the plains are thus exposed. Fig. 3 is the upper portion of such a section about eighty feet perpen-

dicular. The lower portion of the cliff, being covered up by talus, is not represented. It is seen that nearly the whole is an ordinary modified drift, composed of irregularly stratified sands and clays, *cc*, intermingled with layers of pebbles and gravel, *bb*. But there are other parts that deserve more special notice. The stratum *e* is a fine light-colored clay, through which runs a deep chocolate-brown lamina scrolled in the most complex and beautiful pattern; the stratum *d* is also strongly crumpled. This crumpling and scrolling of the strata could have been produced only by a glacier advancing on a bed of stratified clay, or else by the pushing of icebergs on a stratified lake bottom. I suppose the whole formation except *a* to have been produced by an alternately advancing and retreating glacier; now retreating and dropping material, to be carried and deposited by the river which flowed from its snout, now advancing and crumpling the finer material of the lake bottom. It may be difficult to explain the details of the process, but I think it will not be doubted that the whole is a distinctly marked drift-deposit. Many other similar sections were observed; some of which were 150 feet thick.

1.



a = unstratified volcanic sand.
bb = pebble and gravel.
cc = fine sand and clay stratified.
d = strata crumpled by moving strata.
e = strata scrolled by same agency.

Now covering everywhere this undoubted glacial material is found a layer of loose, unstratified volcanic sand and pumice, *a*, which has evidently never been touched by the action of water. It is a pure eolian drift. In the section it is about three feet thick, but it is really much thicker, as it thins off on the margin of the perpendicular cliff by falling, and thus contributes to the talus at its base. It is evident that the whole material of the section was deposited during glacial times, except *a*, which was drifted over the bared lake bottom since that time. But judging from the immense quantity of this loose material, covering as it does the whole plain many feet deep, it seems impossible that it is the mere result of disintegration of the volcanic cones in recent times. I suppose, therefore, that it is the result of sand and ash eruptions since the recession of the lake waters.

3. We have already described the material of the largest island as being composed wholly, except a portion of the eastern part, of a fine infusorial earth, horizontally stratified with laminæ of slightly different colors, so thin as to give specimens an almost agate-like beauty. This material was evidently deposited in the middle and deepest part of the lake, beyond the reach of coarser sediments, at a time when the place of the island was still a lake bottom. Now, that this occurred during or after the epoch of great glaciers, is demonstrated by the fact that scattered sparsely through this fine laminated material, and lying on its surface, having been washed out by erosion, I found many bowlders, both worn and angular, of Sierra granite and slate, and also of obsidian. These could have been brought there only by the agency of floating ice, either as icebergs or as shore ice. If by icebergs, of course during the epoch of great glaciers; if by shore ice, either during that time or still later, for manifestly the bowlders were brought down to the shore from the Sierra during that time. It is evident, therefore, that the stratified mud was formed and the bowlders were dropped during the period of great glaciers or later. But still later the island itself was upheaved by volcanic action, as shown by the anticlinal position of the strata at the base, and by the solfataric action still going on. The formation of this island I suppose to have been coincident with the last eruptions of the volcanoes on the plains.

4. Within the craters of several of the volcanic cones on the plains, I found pebbles and angular fragments of granite of a peculiar reddish color from the presence of a rose-colored feldspar. Whitney observed the same, and accounts for them in the following manner: They could not, he thinks, have been brought by glaciers or by water, for this is inconsistent with the perfect shape of the cones. He rightly concludes therefore that *they must have been* ejected from the volcanoes. But if so, he says, "*they must have been torn off from the underlying granite, through which the eruptive matter has forced its way, as is seen everywhere in the Sierra.*"* On the contrary, I account for them in a wholly different way. The fragments which I saw were some of them angular—true; but *most of them were well-worn pebbles.* There is not the slightest doubt that *these were pebbles of the drift-layer which everywhere underlies the loose sand of the plains.* The eruptive forces broke through this drift-layer, and the ejected pebbles fell back into the crater. They demonstrate that the cones and craters, where they are found, not only

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* Geol. Survey of Cal. vol. i, p. 455.

erupted, but *were wholly formed*, after the epoch of the pebble drift.

I think, therefore, there can be no doubt that all of these volcanoes erupted, and many of them were wholly formed after the epoch of great glaciers (Champlain). Whether any of them preceded that epoch is doubtful. I have never seen any undoubted evidence that they did. If the bowlders found on the island were carried there by icebergs, then volcanic action preceded the epoch of icebergs, for many of the fragments are volcanic; but they may have been carried by shore ice at a later time. Again, I believe the rocky part of the island is older than the sedimentary part, for the latter seems to have been deposited on the former. If the sedimentation was Champlain, then the rocky part was probably pre-glacial; but the sedimentation may have been later.

Sequence of Events.—Assuming that the island strata belong to the epoch of great glaciers, then the order of events was something like this:

1. Volcanic eruptions on the plains producing obsidian, fragments of which were afterwards carried by ice and dropped in mid-lake. At the same time also, the basaltic part of the islands was formed.

2. Then followed the period of great glaciers and flooded lakes, or Champlain epoch. The lake was nearly 700 feet higher than now. Its waters covered the whole plains and washed against the Sierra; and glaciers from this range ran far into the lake and formed icebergs, which floated over its surface and dropped rock-fragments over its fine mud bottom.

3. Volcanic forces, acting quietly like the solfataras and fumaroles still existing, heaved up the stratified mud-bottom of the mid-lake into a gentle mound with quaquaversal dip of the strata, but not rising to the surface. Coincident with this were the eruptions of the plains volcanoes.

4. The lake then dried away gradually to its present level, leaving the terraces as its old flood-marks, and exposing the rounded mud-island; and erosive agents then sculptured this into its present turreted form and cut away its margin to its present limits, and exposed the mud-covered older basaltic part.

Lake rising again.—The existence of salt and alkaline lakes shows an extreme dryness of climate. But the climate of the desert region has not always been dry. During the Champlain epoch the interior plains were covered with immense sheets of water, of which the present saline lakes are the isolated residues. Gilbert has shown that at that time Great Salt Lake contained 400 times as much water as now, and that it drained northward through the Snake and Columbia Rivers into the

Pacific ocean. King has shown that the Nevada basin was at the same time occupied by a vast irregular sheet of nearly equal extent, stretching southward as far as Columbus, Nevada. Pyramid, Winnemucca, Carson, Humboldt, and Walker Lakes, are the concentrated residues of this great lake. Lake Mono also, we have seen, at the same time, was a great sheet of water, whether connected with the other or not is not known. · There has been therefore an increasing dryness of climate in that region since the Champlain. Is it still progressing, or has it reached its maximum? This is an important question for the Pacific States.

From my observations on Lake Mono, I have no doubt that its level, at the time of my visit, was rising and had been rising for ten or fifteen years. The evidence is as follows: Around the margin of the lake I found everywhere old fences of sheep *corrals* and old trails submerged many feet deep. While visiting the island I found the vegetation of the island, sage brush (*Artemisia tridentata*), and grease wood (*Sarcobatus vermiculatus*), submerged in five feet of water, and of course killed. Residents about the lake state that the waters have risen ten to twelve feet in ten or fifteen years. I might be disposed to doubt these observations if the same phenomena had not been observed in other lakes in the same dry region. Salt Lake is known to have risen ten to fourteen feet in twenty five years and submerged large tracts on its flat margins, and the water by analysis is far less salt than formerly. Pyramid Lake, according to King, has risen nine feet, and Winnemucca Lake twenty-two feet in only four years—1867–1871. The same is said to be true of Walker Lake and of Owen Lake.

The cause of this is evidently increase of rain-fall and snow-fall, chiefly the latter. In this connection it may be well to mention an additional evidence of increasing snow-fall in the Sierra. I have in a previous paper† drawn attention to a moving snow-field, or rather an imperfect *glacier*, occupying the great cirque at the top of Mount Lyell, the feeble remnant of the great Tuolumne glacier of glacial times. At the foot of this *glacieret* there is as perfect a terminal moraine as ever was seen. It is a crescentic pile of rock fragments twenty feet high, fifty feet wide at base, and about a mile long. The fragments were brought down by the moving ice from the vertical cliffs of the cirque. Many similar fragments are seen lying on the glacier on their way to the moraine, and in various stages of advance. Now not only does this moraine show no signs of being left by a *retreating* glacier, but on the contrary I think it shows signs that the ice is *advancing*. For the snout of the glacieret is not only pressed hard against the moraine but the outer slope of the moraine, when I saw it, in 1872, was just at the *limit of stability*—the least disturbance caused the fragments to roll down. It would seem therefore that the moraine is being pushed slowly forward. Whether the same is true still I know not.*

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* This Journal, III, v, 325.

King, in his recent volume on Systematic Geology, already referred to, has drawn attention to still other evidence of snow advance in the high Sierra. According to him, above the timber belt, there is a comparatively bare region of one thousand feet vertical, on which for ages there has been too much winter snow to allow the growth of timber. In the timber region bordering the bare region there are many trees which have two hundred and fifty annual rings. These trees have therefore been growing securely for two hundred and fifty years. But since 1860 the snow has so advanced upon the timber region that these great trees are being destroyed by avalanches. It would seem therefore that not only has there been recent advance, but that it is the first advance for two hundred and fifty years.

The rise of the lakes in the desert region is therefore undoubtedly the result of a climatic cycle. But whether the cycle be a long or a short one; whether it be a geological cycle of increasing snow-fall—a turn of the cycle of dryness which, commencing after the Champlain epoch, culminated in the present arid condition of the desert region—or whether it be only a climatic fluctuation of short duration, and of which therefore geology takes no account, such for instance as may be supposed to be connected with the sun-spot cycle, it is impossible with certainty to determine without observations extending through a much longer period of time. I have hitherto been disposed to think the latter more probable, but King's observations on destruction of trees by avalanches, would seem to point to the probability of a long cycle.

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* King, in his recent volume on Systematic Geology of the 40th parallel, p. 477, says that all Mr. Muir's living glaciers of the Sierra are only moving snow-fields well known to the California surveyors. He then quotes Agassiz defining the distinction between such moving névés or snow-fields and true glaciers. This distinction according to Agassiz consists in the ability to bear rock fragments on its bosom and thus to form a moraine. Now, it is but justice to Mr. Muir to say that the ice in the Lyell-Cirque does bear large rock fragments on its surface and accumulates them at its lower limit as a perfect terminal moraine. Recognizing, however, the fact that this ice mass does not emerge from its native cirque, I have, in my paper on "Ancient Glaciers of the Sierra" (this Journal v, 325), called it a *Glacieret*.

Berkeley, California, March 1, 1879.

ART. V.—*On the Mineral Locality in Fairfield County, Connecticut;* by GEORGE J. BRUSH and EDWARD S. DANA. Third paper.

IN the present paper we purpose giving an account of the results of our exploration of the Branchville locality during the past year, so far as they relate to the manganesian phosphates. In our preceding papers,* we have confined ourselves almost exclusively to the original body of phosphates exploited by Mr. Fillow; we having mentioned in addition only the occurrence of a single small deposit of lithiophilite. When we first opened the locality, our hope was to rediscover the body of minerals from which the specimens preserved by Mr. Fillow had been obtained. Our success in this was quite indifferent; we did, indeed, find the spot aimed at, and took from it a small quantity of the minerals in which we were interested, but it was soon clear that this deposit was exhausted, and we must look farther for other and independent ones. Having but little to guide us in our explorations, we extended them quite widely in the seemingly most probable directions and expended, in time and money, more than our final success would, perhaps, have warranted. We discovered, however, many interesting points in regard to the minerals occurring in the vein as a whole, which we intend to describe in another paper.

Lithiophilite.—As regards the phosphates, the mineral lithiophilite has been proved to exist in considerable quantities. It occurs usually not in large deposits, but in single, isolated masses, from the size of a cherry to others several inches across. The method of occurrence is quite uniform. The masses are irregular in shape, sometimes rounded, sometimes angular, and interpenetrating the associated minerals in the most intimate manner. These associated minerals are more particularly feldspar, usually albite, and spodumene. The latter mineral is very generally altered, and the various products of its alteration, of which cymatolite is the most common, we shall describe in another place. The lithiophilite, however, though often coated black externally, is otherwise quite free from alteration; the only exception to this was in the case of that first discovered, which was situated near the surface of the ledge and was much oxidized. It will be remembered that, in what we have alluded to as the original deposits of phosphates, the lithiophilite occurred very sparingly and only as an occasional nucleus of masses of the abundant black mineral, the product of its alteration. This is described in our preceding paper, and analyses of these oxidation products are there given.

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* This Journal, July and August, 1878, May, 1879.

The lithiophilite of which we are now speaking has, in almost all cases, the salmon color of that first described. In one specimen the amount of iron was determined by Mr. Penfield and found to be but 3·56 per cent. The lithiophilite sometimes contains imbedded rhodochrosite. Other constantly associated minerals are: apatite, garnet, uraninite in brilliant black octahedrons, uranium phosphates, and a silicate containing uranium, near cyrtolite, all of which will be described later.

The lithiophilite was the only mineral of the manganesian phosphate group found in these small, isolated deposits. A larger mass finally reached, however, gave us another variety of this mineral, and also several of the other species. This mass was of so peculiar a nature as to deserve a somewhat minute description. It afforded first, for the most part, only lithiophilite, but of a different color from that before obtained, and of slightly different composition as shown by the analysis given on p. 47. Closely associated with the lithiophilite was a considerable amount of a granular, often also cellular, manganesian carbonate, rhodochrosite. This was quite impure, often containing interpenetrated crystals of white apatite, and also quartz. With the lithiophilite and rhodochrosite, are small quantities of eosphorite and triploidite and traces of dickinsonite; we were interested in finding hand specimens, showing all these phosphates together, entirely free from alteration, and in such a juxtaposition as to seem to prove a contemporaneous origin. Crystallized out in cavities in the rhodochrosite and again in thin seams or strings through it was a reddish-brown mineral which proved to be chabazite.

Immediately connected with the minerals described, was a large mass of a green chloritic mineral, of which we took out some hundred pounds; this we describe minutely on a subsequent page. Its especial interest lay in the intimate manner in which it was associated with the minerals just mentioned. This is particularly true of the eosphorite, which was scattered irregularly through it in nodules of great variety in shape and size. These nodules have often a banded coating of a firm whitish substance, which may have been derived from the alteration of the original mineral, and which entirely conceals the eosphorite within.

Having given this general description of the method of occurrence of these minerals, we will now proceed to describe some of them more minutely.

LITHIOPHILITE.

We have already stated, that almost all of the lithiophilite discovered was similar in its salmon, and salmon-pink color, and, as far as tested, in composition, to that described in our first paper; in other words, it contains from three to four per cent of iron protoxide. The lithiophilite, associated with the green chloritic mineral, has a light clove-brown color. It has a brilliant luster and is clear and transparent. The specific gravity is 3·482. An analysis* by Mr. S. L. Penfield, afforded the following results:—

	I.	II.	Mean.	Atomic relation.		
P_2O_5	45·22	45·22	45·22	P	----	·636
FeO	13·10	12·92	13·01	Fe	·180	= ·631
MnO	31·93	32·12	32·02	Mn	·451	
Li_2O	9·26	----	9·26	Li	·618	= ·628
Na_2O	0·28	0·30	0·29	Na	·010	
H_2O	0·17	----	0·17			
Gangue	0·31	0·28	0·29			
			100·26			

The ratio, $P : \overset{II}{R} : \overset{I}{R} = {\cdot}636 : {\cdot}631 : {\cdot}628$, corresponds very closely with the formula previously accepted,

$$\overset{I}{R}\overset{II}{R}PO_4 \text{ or } \overset{I}{R}_3PO_4 + \overset{II}{R}_3P_2O_8.$$

It will be observed that the amount of iron in this variety of the mineral is considerably greater than in that first described and alluded to above. This result is not surprising, and indeed was anticipated from the color of the specimen. Mr. Penfield, in the article referred to, has brought together the analyses of several varieties of triphylite and the two of lithiophilite, and thus shows the gradations between the two species. The one extreme is the Bodenmais triphylite with 36·21 p. c. FeO, and 8·96 p. c. MnO, and the other the original lithiophilite, with 4·02 p. c. FeO, and 40·86 p. c. MnO. The relation between these two minerals, is closely analogous to that existing between the iron and manganese carbonates, siderite ($FeCO_3$), and rhodochrosite ($MnCO_3$). There is the same similarity in physical characters, the most pronounced difference being here as there in the color, so that the necessity of giving the two minerals of the triphylite group distinct names cannot be questioned.

EOSPHORITE.

The eosphorite we have spoken of as forming nodules imbedded in the massive green chloritic mineral. It occurs only massive, but shows the characteristic cleavage distinctly and is clear and lustrous. The color is a beautiful pink, sometimes quite deep. The specific gravity is 3·11. An analysis by Mr. Horace L. Wells gave the following results:—

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* This analysis has already been published by Mr. Penfield in an article on the composition of triphylite; this Journal, March, 1879.

			Ratio.	
P_2O_5	31·39	P_2O_5	·221	1·06
$\bar{A}lO_3$	21·34	$\bar{A}lO_3$	·208	1·
FeO	6·62	FeO	·323	2·12
MnO	22·92	MnO	·092	
CaO	1·48	CaO	·026	
H_2O	15·28	H_2O	·849	4·04
Insol.	1·46			
	100·49			

The ratio of $P_2O_5 : \bar{A}lO_3 : RO : H_2O$ is very nearly 1 : 1 : 2 : 4 or that given in our former paper, and upon which the formula was based, viz :—

$$R_2\bar{A}lP_2O_{10}, 4H_2O \text{ or } \bar{A}lP_2O_8 + 2H_2(Mn,Fe)O_2 + 2aq.$$

THE GREEN MINERAL.

The larger part of this deposit consisted, as already stated, of a soft green compact mineral, varying in tint from light grayish and yellowish-green to dark blackish-green. Luster dull to greasy. Hardness = 2·5. Specific gravity of the purest portions = 2·85 to 2·89. This material was exceedingly impure, containing, imbedded in it, the feldspar and mica of the vein, also quartz, apatite, chabazite, as well as the phosphates, most conspicuously among these, the eosphorite. It was possible, however, to obtain small hand specimens showing the green mineral in a state of comparative purity. A series of ten thin sections was prepared from specimens which appeared most homogeneous, and these were carefully examined under the microscope. It was found from them, that the substance was, for the most part, fine granular and crypto-crystalline, but that numerous quartz grains and apatite needles were scattered through it. The crypto-crystalline ground-mass could not be resolved under the microscope and had every appearance of homogeneity, but it would be unsafe, considering the nature of the substance, to assert this positively. In any case the presence of distinct, though microscopic impurities, makes it quite hopeless to think of obtaining a definite chemical composition.

A specimen as pure as we were able to obtain, has been analyzed by Mr. Horace L. Wells with the following result:—

	I.	II.	Mean.	Ratios.
SiO_2	20·71	20·73	20·72	·345
$\bar{A}lO_3$	14·71	14·64	14·67	·158
$\bar{F}eO_3$	2·67	2·67	2·67	·016
FeO	19·48	19·65	19·56	·272
MnO	2·21	2·23	2·22	·031
MgO	5·22	5·16	5·19	·130
Na_2O	0·51	----	·51	·008
K_2O	0·09	----	·09	·001
Li_2O	*tr.*	----	*tr.*	
CaO	12·40	12·27	12·34	·220
P_2O_5	8·81	8·87	8·84	·622
Insol.	3·84	3·94	3·89	
H_2O	8·83	8·84	8·84	·491
			99·54	

It is evident from the above, independent of the microscopic examination, that the substance analyzed is not a simple mineral. If we assume the 8·84 per cent of phosphoric acid to be combined with sufficient lime to form the mineral apatite, and deduct this amount and also the insoluble matter, we have a remainder of 75·19 per cent, which when calculated to the original amount gives the following composition:—

SiO_2	27·43	MgO	6·87
$\bar{A}lO_3$	19·42	CaO	0·95
$\bar{F}eO_3$	3·54	Na_2O	0·68
FeO	25·89	K_2O	0·12
MnO	2·94	H_2O	11·70
			99·54

It is scarcely admissible to attempt a formula for a substance which is so evidently a mixture, but we believe the results indicate that the green mineral is unquestionably a variety of chlorite. The analysis, excluding apatite and the insoluble residue, brings the composition very near that of delessite and prochlorite. Its physical characters, also, confirm its claim to be referred to the chlorite group.

The mineral gives water in the closed tube, and B. B. fuses to a black magnetic mass; with the fluxes it reacts for silica, iron and manganese. Soluble in hydrochloric acid with separation of silica, and an insoluble residue which was separated from the silica by solution of the latter in boiling carbonate of soda. The insoluble residue proved to be a silicate of alumina, possibly cymatolite which occurs at the locality in great abundance.

CHABAZITE.

This species occurs of a dark yellowish to reddish brown color, in irregular masses disseminated through quartz, and sometimes imbedded directly in the green chloritic mineral, and also in the massive manganesian carbonate occurring with the lithiophilite. A few small crystals, $\frac{1}{4}$ to $\frac{1}{2}$ inch over, were found in cavities. This singular mode of occurrence, in irregular spots and strings imbedded in other species, was so unlike the ordinary association of chabazite, that we could scarcely credit its being this species, although the pyrognostic characters, rhombohedral form ($R \wedge R = 96° 45'$), density, hardness and other physical characters plainly indicated its specific relations. The analysis given below, however, renders its identification with chabazite complete; this analysis was made by Mr. Penfield on the purest material which could be obtained. It was found impossible to separate it entirely from the quartz.

The chabazite has a vitreous to sub-resinous luster. The hardness is 4·5 and the specific gravity is 2·16.

An analysis of a carefully selected specimen by S. L. Penfield gave

Silica	49·22
Alumina	17·58
Iron sesquioxide	1·99
Manganese protoxide	0·56
Lime	6·73
Potash	2·83
Soda	1·44
Water	17·83
Quartz	2·78
	100·96

RHODOCHROSITE.

It will be seen from what has been said in this and in our first paper, that rhodochrosite is a very common mineral in its association with the phosphates. In the first deposit it occurred sometimes in specimens of large size with the characteristic color and cleavage ($R \wedge R = 106° 49'$), and again in granular aggregates interpenetrated with quartz, and often taking a greenish color from the dickinsonite. It also appears altered to a black, highly lustrous mineral, containing only the oxides of iron and manganese.

In the deposits which form the special subject of this paper, the rhodochrosite occurs first of a pink color implanted in the lithiophilite and hardly to be distinguished from it except by its cleavage; and again in large masses of a white or faintly pink color, granular texture, and made very impure from the admixture of quartz and apatite. This variety of the mineral occurs with the clove-brown lithiophilite and the green chloritic mineral, and contains in cavities crystals of quartz, apatite and chabazite. We add here an analysis by Mr. S. L. Penfield, of the first discovered rhodochrosite; specific gravity = 3·76.

	I.	II.	Mean.	Ratio.		
CO_2	37.78	37·80	37·80		·859	1
FeO	16·74	16·78	16·76	·233		
MnO	44·68	44·50	44·59	·628	·867	1
CaO	0·33	0·33	0·33	·006		
MgO	*tr.*	*tr.*	*tr.*			
Insoluble	0·35	0·29	0·32			
	99·88	99·70	99·80			

The variation in color of the mineral implies that the composition varies widely, which would doubtless be shown, could analyses of different varieties be made. The interest connected with the subject is, however, small, although the large amount of iron present is worthy of note.

ART. VI.—*Note on the Progress of Experiments for comparing a Wave-length with a Meter*; by C. S. PEIRCE. Communicated by the Superintendent of the U. S. Coast and Geodetic Survey.

To C. P. PATTERSON, Superintendent U. S. Coast and Geodetic Survey:—

DEAR SIR—The following is the present state of the spectrum meter business. The deviation of a spectral line (Van der Willigen's No. 16) has had three complete measures using a certain gitter of 340½ lines to the millimeter. The double deviation (the angle measured) was found to be

1877.	June 23,	89° 54′ 19″·5
	June 29 and July 2,	19·25
	Sep. 4 and Aug. 27,	19·65
	Mean,	89° 54′ 19″·5

An error of 0·4″ in this would occasion an error of one micron in the meter. These measures were previously communicated to you, but owing to an erroneous value of the coefficient of expansion of glass having been used (the value for iron having been inadvertently substituted) they did not seem to agree as well as they do. There were two other complete measures, but in regard to one of them there is a doubt about the thermometer used, and in regard to the other there is a doubt about the part of the line set on. This line seems on the whole to be a bad one for the purpose. Another line near it was therefore selected and another much finer gitter. The deviations obtained were on the different days:

1879.	May 8,	90° 03′ 51″·7	May 15,	90° 03′ 50·35
	May 9,	51·75	May 21,	51·75
	May 10,	52·0	May 22,	51·2
		Mean, 90° 03′ 51″·45		

Notwithstanding the bad result of May 15, which is unaccountable, these measures are evidently good enough. One of these gitters has been compared with all the centimeters of a decimeter scale of centimeters. The other is still to be compared with all the even two centimeters of the same scale.

Mr. Chapman is now comparing this decimeter scale with all the decimeters of a meter scale of decimeters. As soon as that is done *a meter* will have been compared with a wave-length. But shortly after, this will be improved by comparing the other gitter and also a third upon which I propose to measure a deviation. It will remain, first, to find the coefficient of expansion of the glass meter. The apparatus is all ready for this and it will not take a fortnight. Second, the glass meter will have to be compared with a brass meter. This will be an operation of some difficulty but I think we shall complete it before long.

Yours respectfully, C. S. PEIRCE, *Assistant.*

Art. VII.—*Notice of recent Additions to the Marine Fauna of the Eastern Coast of North America, No.* 6; by A. E. Verrill. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLIII.

Polyzoa.

Bugula decorata, sp. nov.

Zoarium rather large with thick, much branched stems, producing densely branched, somewhat plumose tufts, two inches or more high. Branches unequally dichotomous, often somewhat spirally arranged. Zoœcia in two alternating rows, large, broad, prolonged proximally. Frontal area, large, elongated, sunken and wrinkled in the dry state. The distal angles are prolonged into a single stout, often short spine on each side, frequently absent on the inner angle. Avicularia on the middle of the front side of the zoœcia, toward the base; they have a short, broad, swollen head, with a short strongly curved beak; the pedicels are short and thick, rapidly enlarged from the base upward. Oœcia large, globose, brilliantly iridescent, elegantly sculptured, with a series of raised curved lines passing up over each side and converging to the middle of front side, while their concave interspaces are covered with microscopic transverse lines. Dredged at Eastport, Me., by the writer, and also in the Gulf of Maine, 110 fathoms, near George's Bank, by Dr. A. S. Packard and Mr. C. Cooke, in 1872 (U. S. Fish Com.). The other species of *Bugula* found on the New England coast are as follows:

Bugula cucullata, sp. nov. Off Maine. Remarkable for the small, hood-like, upturned oœcia, widely open in front. Zoœcia in two rows; usually two spines on each angle; avicularia lateral.

Bugula turrita (Desor) Verrill. Florida to Casco Bay.

Bugula avicularia (L.) Oken. Long I. Sound to Spitzbergen.

Bugula fastigiata (L.) Alder (= *B. plumosa* Busk). Mass. Bay to Labrador; Europe. Perhaps a variety of the last.

Bugula flustroides (Lamx.) (= *B. flabellata* Gray). Long I. Sd. to Maine; Europe.

Bugula Murrayana Busk. Long I. Sd. to Europe.

B. Murrayana, var. *fruticosa* (Packard).

Bugula flexilis Verrill and *Bugula umbella* Smitt, belong to the genus *Kinetoskias* Dub. and Kor. Both occur in deep water off Maine and Nova Scotia.

Notwithstanding the very numerous restrictions which the ancient genus *Cellularia* has undergone, it is still made to include heterogeneous species by several recent writers, while others restrict it to groups not originally included by Pallas. In the excellent memoirs of Smitt on the Arctic Bryozoa, five species still remain in the genus *Cellularia*. These belong to three well-marked groups, and their synonymy is very complicated. Having had occasion to revise this family, I offer the following summary of the New England species.

I. *Cellularia* Pallas, 1766, (restricted). Zoœcia unilateral, in two alternating rows, mostly protected by lateral spines, either simple or dilated. Vibracula and lateral and median avicularia present. Type *C. scruposa.**

a. Subgenus *Cellularia.* (=*Scrupocellaria*, *pars*, Gray, Busk). Lateral spines all simple.

b. Sub-genus *Cellarina* Van Ben. (incl. *Tricellaria* Flem., 1828.) One of the lateral spines usually more or less dilated, and often expanded in a shield-like form in front of the zoœcia. Two New England species: *C. scabra* Van Ben.; and *C. ternata* (Sol.) with varieties *gracilis* and *duplex* (Smitt).

The name *Tricellaria*, (given to *ternata*), might have been adopted for this subgenus, but is very inapplicable to the group, and even to the type-species, as now known.

II. *Scruparia* Oken (restricted), (= *Scrupocellaria*, *pars*, Gray; *Canda* Busk, *non* Lamx.). Lateral avicularia and vibracula absent. A lateral spine develops into a protective (often frondose) shield. Type *S. reptans* (Linné), not yet found on the American coast.

III. *Bugulopsis* Verrill (= *Cellularia*, *pars*, Busk, *non* Pallas). Characterized by the simple, unarmed zoœcia, arranged in alternating rows, and destitute of avicularia, vibracula and shields. Type *B. Peachii* (Busk). Gulf of Maine and Bay of Fundy. European seas, north to Spitzbergen.

As no species of the last group was originally included in *Cellularia*, it is inadmissible to restrict that name to it. Therefore either *reptans* or *scruposa* should be taken as the type of *Cellularia*, both having been originally included by Pallas, as well as by most subsequent authors. *Scruparia*† Oken (1815) originally included not only the group that had previously been named *Eucratea* by Lamouroux (1812), but also *S. reptans*. Therefore there seems to be no good reason why it should not be restricted, as above, rather than be displaced by the much later and more objectionable name, *Scrupocellaria*. *Menipea*, used by Busk and others for *Cellarina*, is inadmissible, in that sense, for the original group thus named by Lamouroux is a valid and very distinct genus. *Canda* (Lamx., 1816), adopted by some for *Cellularia reptans*, cannot properly be so used, for the original type is a distinct genus.

***Porellina stellata*, sp. nov.**

A large, handsome species, forming radiating patches on shells, etc. Zoœcia arranged in quincunx, large, broad, moderately convex, white, shining, mostly imperforate and smooth, the marginal ones more or less perforate in front. Apertures nearly semi-circular, the proximal edge straight or nearly so, often with two spines on the distal border, median pore, a short distance from the aperture, large, nearly circular, provided with numerous, slender, convergent spinules, which nearly reach the center, giving the pore a stellate appearance. Avicularia near the lateral margin, about opposite the median pore, varying in size and form: in the same colony some are short triangular, others long triangular, while others with a long and acute, erect tip show the transition toward vibracula. Length of zoœcia, ·60 to ·70^{mm}; breadth, ·50 to ·60^{mm}; breadth of apertures, ·12 to ·15^{mm}; of median pore, ·05 to ·06^{mm}. The zoœcia are about twice as large as those of *P. ciliata.*

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* This species has been recorded from the Gulf of St. Lawrence by Packard and others, but I have myself seen no American examples.

† This name has recently been given to a new genus, in a new sense, by Hincks, in accordance with a practice that is nearly always unsafe, as well as confusing.

Casco Bay, Maine. (U. S. Fish Comm., 1873).

In the nearly circular form of the median pore this species approaches the genus *Porina*, as restricted by Smitt, (Florida Bryozoa), but in all other respects, except size, it agrees so closely with *P. ciliata*, made the type of *Porellina* by Smitt, as to forbid a generic separation, although the latter has a crescent-shaped pore. It would belong to *Microporella* Hincks, if that name be adopted.

ART. VIII.—*Positions of the Planets Philomela and Adcona;* by C. H. F. PETERS.

I COMMUNICATE a few observations on a planet discovered by me on the 14th of May. I have given to it the name *Philomela*, as the name *Prokne* is applied to the one discovered on March 21. The planet lately found (May 21) by Mr. Palisa seems to be *Adcona* (145), which for several years had been searched for in vain, its elements having remained very uncertain, since my observations at its first appearance, the only ones made upon it, did not extend over more than about a month (from June 3 until July 7, 1875). I append the two positions I succeeded in getting before the last moon.

Observations on *Philomela* (196).

1879.	Ham. Coll. m. t.	App. α.	App. δ.	log (p. "Δ)	No. of comp.
May 14.	$11^h\ 56^m\ 31^s$	$12^h\ 16^m\ 39^s{\cdot}02$	$+6°52'46''{\cdot}9$	0·682 0·736	12
16.	10 37 6	12 16 21·21	6 48 5·7	0·509 0·724	10
18.	12 25 36	12 16 6·75	6 42 30·7	0·747 0·746	10
20.	9 51 4	12 15 58·20	6 36 57·0	0·391 0·723	12
25.	10 22 18	12 15 57·02	6 19 57·8	0·572 0·731	10
June 5.	10 6 55	12 17 37·14	+5 32 34·6	0·634 0·742	9

Observations on *Adcona* (145) (?).

1879.	Ham. Coll. m. t.	App. α.	App. δ.	log (p. "Δ)	No. of comp.
May 28.	$14^h\ 27^m\ 1^s$	$15^h\ 55^m\ 11^s{\cdot}71$	$-15°30'22''{\cdot}8$	0·677 0·851	8; 4
29.	12 40 30	15 54 18·81	−15 30 54·6	0:343 0·875	12

Litchfield Observatory of Hamilton College, Clinton, N. Y., June 6, 1879.

ART. IX.—*A Method of Preventing the too rapid Combustion of the Carbons in the Electric Lamp;* by H. W. WILEY.

IN using the electric light for projections, two chief points are to be considered, viz: 1st, brilliancy of illumination, and 2d, steadiness of the light. When the source of electricity is sufficient, the first of these ends is easily obtained. The second, however, is not so easy of accomplishment. The chief difficulty in the way of securing steadiness is found in the carbons themselves. Some carbons, and I find these to be the most common, burn away so rapidly that, where no mechanism is present to produce alternating currents, the electric arc is constantly passing out of the focus. Often, too, I have found that when the current is quite strong with the softer carbons, the arc would extend itself momentarily between points as far as a centimeter from the end of the carbons. At other times it would revolve about the electrodes something like a spiral flame in a pyrotechnic display. This leaping and dancing of the arc is, of course, fatal to its employment for projection.

In order, if possible, to remedy these defects in a lantern which I have in almost daily use, I made the following experiments. I first took the specific gravity of three specimens of carbon, obtained from different dealers, one in France and two in this country. The specific gravity of the French carbon, was 1·85; of No. 1, American, 1·53; of No. 2, American, 1·55. The French carbon is hard, of a grayish black color. The American carbon is soft, easily broken up, and has no sign of a metallic luster. The light from the French carbon is quite steady and displays very little of that tendency to flicker, so troublesome in the American varieties.

A positive French carbon, which had been used for several hours, until consumed nearly to the lamp, burned away at the point, but otherwise retained its original shape. This carbon was used without any previous preparation.

A soft carbon, however, of the same size as the preceding, became red hot to a distance of four to six centimeters from the end, and rapidly wasted away; after being in use for half an hour, it was reduced to a slender, tapering form.

I first tried the plan so well known in France, but so seldom tried here, of coating the carbons with a film of copper. The precipitation of the copper should take place slowly, and with a current so regulated in quantity and intensity as to produce no spongy deposits. When the soft carbons were thus prepared they worked beautifully for a short time. The light was brilliant and steady, while any green tint imparted to it by the volatilized copper produced no effect whatever prejudicial to the purpose in view. But as the carbons, little by little, became heated, the copper film oxidized, and after half an hour the carbon was again reduced to the slender form above described.

I next tried the expedient of setting a copper wire, ·4^{mm} in diameter, into the center of the carbons. With a thin saw I cut a longitudinal groove to the center of the carbon, and after inserting the wire fixed it in place by filling the groove with plaster. The upper end of the wire was left projecting so that it could be brought into actual contact with the clamp. I hoped from this contrivance to hold the origin of the arc steadily at the end of the carbon and, at the same time by increasing the conducting power, to prevent the heating and consequent rapid consumption of the electrode. In placing the carbons in the lamp the grooved sides were turned from the lens. This device proved very successful in securing a steady light, but the carbons were heated to their points of insertion in the holders and wasted rapidly away. The point, it is true, remained blunt, but the stem of the carbon burned away so rapidly that the experiment must be regarded as unsuccessful.

It was evident from my first experiments with copper-plated carbons, that, if any way could be devised of protecting the copper from oxidation, the copper would prevent the carbon from heating by increasing its conductivity, and diminishing the resistance. I accordingly covered the carbons, after copper-plating with a film of plaster of Paris, about 1^{mm} in thickness. After this had set, the edge of the carbon, which was to be turned towards the condenser, was carefully denuded of its plaster-covering, which was also cut away until quite thin on the adjacent surfaces. These precautions were taken so that the plaster might not interfere with the radiation of light in the direction of the condenser. Before use the plaster must be thoroughly and slowly dried. The copper surface at the end of the carbon being uncovered it is fastened in the holder in the usual way. The carbons prepared in the way described left nothing to be desired. The light was steady and the carbons burned slowly away. The film of plaster melted gradually as the point was consumed and thus never interfered with the illumination. The points of both positive and negative carbons remained blunt, and there was no wasting away of the stem. A carbon prepared in this way will last at least ten times as long as one used in the ordinary way. But the chief advantage is found in the comparative steadiness of the light thus secured.

Carbons of the above description work best when well plated. The following numbers give what I regard as a minimum amount of copper to secure satisfactory results. In all the experiments I have tried, the carbon has been of the soft American variety, with an average specific gravity of 1·55.

Length of carbon, ...	17·5 cm.
Each side, ...	1 "
Number $\overline{\text{cm.}}^{2}$ of surface including ends, ...	72 $\overline{\text{cm.}}^{2}$
Weight before coppering, ...	21·1615 g.
Weight after coppering, ...	24·0410 "
Weight of copper, ...	2·8795 "
Weight copper to each $\overline{\text{cm.}}^{2}$, ...	·0397

In order to dispense with the use of a reflector, I arrange the carbons + above as described in the Journal of Franklin Institute for May and June, 1878.

The peculiar cup-shaped appearance of the positive carbon helps to concentrate the light on the condenser. It is understood that any lamp, in which the carbons are arranged end to end, can be used with electrodes prepared as above. Such a lamp can be easily substituted in a lantern made for use with oxy-hydro-lime light. I use constantly such a lamp with one of Edgerton's physical lanterns originally made for the lime light. I am inclined to think a kaolin paste would be better than plaster for coating the carbons. The electric force used in all the experiments has been furnished by the Gramme machine, described in the Journal of the Franklin Institute already cited.

The use of projections for illustration in lectures on Chemistry and Physics has become so general that I hope the suggestions in this paper may prove of some benefit.

Purdue University, Lafayette, Indiana, April 18, 1879.

ART. X.—*Bernardinite: a new Mineral Resin from San Bernardino County, Cal.;* by J. M. STILLMAN, Ph.B.

THROUGH the kindness of Mr. B. B. Redding, of San Francisco, I have been put in possession of some specimens of a new and interesting mineral said to occur in considerable quantity in San Bernardino County, California, and exposed by excavations for a tunnel. The pieces in my possession were homogeneous masses of from one to five or six cubic inches dimensions, and appeared to have been broken from still larger masses. It presents a nearly white mass, friable, light and porous, containing much enclosed air, so that it floats on water like cork. On fracture it presents a slightly fibrous structure. Under the microscope it exhibits a two-fold structure—a quantity of very fine irregular fibers permeating a mass of a brittle, amorphous, structureless substance. No definite structure could be perceived indicating previous woody or vegetable tissue. The specific gravity of the mineral freed from air was determined as 1·166 at 18° C. The mineral does not melt perfectly at 140° C., but softens *slightly* at temperatures below 100° C.

It is insoluble in water;—entirely soluble in hot absolute alcohol, about 86·6 per cent dissolving on boiling for some time. The soluble portion is quite soluble, remaining in solution in about 2½ parts of hot alcohol. In cold absolute alcohol it is not so soluble, about one-third of that portion soluble in hot alcohol, not re-dissolving in cold. The alcoholic solutions are of a slightly yellow color, marked bitter taste, and acid reaction. Ether dissolves about one-third of the native mineral at ordinary temperatures. Carbon disulphide dissolves it but slightly. The residues from the solutions were in every case white and amorphous.

The extract with hot alcohol melts at temperatures between 115° and 125° C., but has no constant melting point, and softens somewhat at lower temperatures. On cooling after fusion it forms a brittle, translucent mass. Heated on platinum foil the mineral burns with smoky flame, with fixed carbon residue, but with only a trace of ash. An ash determination gave 00·12 per cent of a white, infusible ash, evidently silica. With concentrated sulphuric acid it gives a red-brown color, which on warming becomes black; on dilution with water black flakes are precipitated. The mineral, dried for several days over sulphuric acid, lost on heating to temperatures below its melting point 3·87 per cent in weight, probably, though not certainly, water. It contains no nitrogen. Elementary analysis of the mineral dried over sulphuric acid gave—

Carbon = 64·53 per cent.
Hydrogen = 9·20 "
Hence Oxygen = 26·27 "
100·00

Admitting the loss in weight above quoted, of 3·87 per cent, as being due to loss of water, we should have as a complete analysis—

Water	3·87	per cent.
Carbon	64·46	"
Hydrogen (not in water)	8·75	"
Oxygen (not in water)	22·80	"
Ash	0·12	"
	100·00	

In caustic potash the mineral dissolves very readily and almost completely (93·5 per cent). The solution when concentrated is of a light, clear, brownish-yellow, and may be diluted to any extent with distilled water without precipitation, but with dilute chlorhydric acid gives a flocculent precipitate which settles to the bottom on standing. The alkaline solution is gelatinous in the cold when concentrated, but dissolves on dilution, and gives a froth like soap-suds on agitation. The portion insoluble in caustic potash (6·5 per cent) is left as a glue-like mass of a brownish color.

A quantity of the mineral was dissolved in caustic potash, precipitated with chlorhydric acid; the resin thus obtained was subjected after drying to elementary analysis. It gave—

$$\left.\begin{array}{lcl}\text{Carbon} & = & 69\cdot71 \text{ per cent.}\\ \text{Hydrogen} & = & 9\cdot59 \quad \text{"} \\ \text{Oxygen} & = & 20\cdot70 \quad \text{"}\end{array}\right\} 100\cdot00$$

The melting point of this purified resin was determined at 127°–129° for perfect fusion, though softening at lower temperatures.

The acid character of the alcoholic solution, the oxygen contents, the behavior toward solvents, and especially toward caustic potash, as well as the temperature at which it melts, all indicate the resinous character of the new mineral. To confirm this it was treated in alcoholic solution with alcoholic solution of lead acetate, and a flocculent, white precipitate of the lead resinate was obtained. It is noticeable that the oxygen contents of this resin, as evidenced by both analyses, is much greater than is usually found in resins either of mineral origin or freshly obtained from plants.

The filtrate, obtained by dissolving in caustic potash and precipitating with chlorhydric acid, was evaporated to dryness and exhausted with alcohol, and a small quantity of a yellowish waxy substance obtained of an intense bitter taste, evidently the substance to which the bitter taste of the mineral as well as of its alcoholic extract is due, as the purified resin possessed no bitter taste.

This new resin appears to possess entirely different properties and composition from any organic mineral heretofore described. The South American mineral Guyaquillite seems to resemble it in some properties, but differs very materially in other essential properties as well as in composition. Berengelite, also from South America, possesses a somewhat similar elementary composition ($C_{20}H_{30}O_4$), but differs in all other essential properties. At the suggestion of Mr. Redding, to whom I am indebted for the specimens which form the subject of the foregoing examination, I propose the name of *Bernardinite* for the new mineral, from the name of the locality.

I hope soon to be able to subject the mineral to a more thorough investigation, with the object of ascertaining the true chemical nature of its constituents.

University of California, February, 1879.

Art. XI.—*Notice of a new Jurassic Mammal;* by Professor O. C. Marsh.

During a recent visit to the Rocky Mountains the writer spent some time in examining the deposits known as the Atlantosaurus beds, and was rewarded by the discovery of several interesting fossils, among them the lower jaw of a small mammal. This specimen indicates a dimunitive marsupial, quite distinct from the one previously described by the writer from the same horizon (*Dryolestes priscus*),* which has hitherto been the only mammal known from the Jurassic of this country.

The present specimen, which is from the left side, has the larger part of the ramus preserved, with a number of perfect teeth in position. Most of the symphysial portion is lost, and the posterior part is missing, or only faintly indicated. The jaw was remarkably long and slender. The horizontal portion is of nearly equal depth throughout, and the lower margin nearly straight. The form of the coronoid process, condyle, and angle of the jaw cannot be determined from this specimen.

The remarkable feature in this jaw is the series of premolar and molar teeth. These were very numerous, apparently as many as twelve in all, and possibly more. The premolars had their crowns more or less compressed, and recurved, and some of them were supported by two fangs. These had a small posterior tubercle at the base of the crown, but none in front. The molar teeth were all single-fanged, with elevated conical crowns. Those preserved have a distinct cingulum. The molars increase in size from the first to the fifth. All the teeth preserved have the crowns raised considerably above the upper margin of the jaw, and thus appear to be loosely inserted. A large pointed tooth lying near the jaw appears to be a canine.

The principal dimensions of this specimen are as follows:

Length of portion of jaw preserved	11·5 mm
Extent of five molar teeth	4·
Extent of entire molar series	5·
Height of fifth true molar above jaw	2·
Depth of jaw below fifth molar	1·75
Depth of jaw below last premolar	1·5
Depth of jaw below first premolar	1·4

In comparing this interesting fossil with the forms already known, it is at once evident that it differs widely from any living type. Its nearest affinities are clearly with the genus *Stylodon* of Owen, from the Purbeck beds of England,† and in many respects the correspondence is close.

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* This Journal, vol. xv, p. 459, June, 1878.

† Geological Magazine, vol. iii, p. 199, 1866, and Palæontographical Society, vol. xxiv, p. 45, 1871.

This specimen clearly indicates a new genus, which may be called *Stylacodon*, and the species represented, *Stylacodon gracilis*. With the genus *Stylodon*, this form evidently constitutes a distinct family, which may appropriately be termed the *Stylodontidæ*. The present specimen indicates an animal somewhat smaller than a weasel, and probably insectivorous in habit.

Yale College, New Haven, June 18th, 1879.

ART. XII.—*On the Hudson River Age of the Taconic Schists;* by JAMES D. DANA. Supplement.

In the preceding part of this paper, the courses of the bedding of the rocks are indicated only in a general way. In this supplement, I give the results observed in Dutchess County as to strike and dip, together with some other omitted details.

1. *Wappinger-Valley Belt.* — This limestone belt leaves the Wappinger Valley about a mile northeast of Salt Point (or five miles from Pleasant Valley), the Creek—not the limestone belt—here changing its course by taking an eastward turn for a mile. From this point it has a small brook, flowing from Upton's Lake, as its southern limit, instead of the Wappinger stream; at the same time, its width—which was nearly a mile at Manchester, 3000 feet at Pleasant Valley, and, according to Professor Dwight, 2200 at Salt Point, continues to diminish; and, about half a mile west of Willow Brook station, the southern part of the belt ends. It appears again in the Wappinger Valley, about two and a half miles to the eastward, north of Bangall. The following are the results obtained with reference to the strike (or direction of bedding, allowance being made for variation, and the dip of the limestone and the associated schist) commencing at the south. As has been stated, the schist in Dutchess County, going from west to east, varies very gradually from dull to shining argillyte and thence to hydromica schist, on the north; and, on the south, from the same to mica schist and micaceous gneiss.

At East Mills, 4½m. S.E. of Poughkeepsie, the schist east of Wappinger Creek, strikes N. 39°–40° E., dip 75° E. (that is, eastward, but at right angles to the strike). At Manchester, limestone N. 17°–25° E., dip 50°–60° E.; schist, E. of river, N. 20°–21° E., 60° E.; the width of the limestone east of creek, about 2000 feet, and west of it, 3000 feet. At Rochdale (Titus's woolen factory) fossiliferous limestone, N. 37° E., dip 60° E. (650 feet west of the eastern junction with the slate). At Pleasant Valley, where the limestone is almost wholly north of the creek, N. 32° E., dip 85°–90° E., at a locality not far from its northwestern limit; and at the quarry near the river, about 200 yards from the southeastern limit, N. 24° E., dip 60° E. At Salt Point, according to Professor Dwight, N. 26° E., dip 70°–85° W. Southwest of Willow Brook ¾ m., limestone N. 19° E., dip 50°–60° E.; a mile east of Willow Brook, S. side of Wappinger Creek, schist N. 16° E., dip 60° E., and ½ m. N.E. of last, N. 14° E., dip 50°–60° E. At Stanfordville, schist S. of river, N. 28° E. (average), dip 60° E. (varying, much contorted); 200 yards above station N. of river, *a layer of grayish quartzyte in the schist,* 25 to 30 feet thick, strike of slate and quartzyte, N. 16° E., dip 60° E.; just north of river ½ m. W. of Bangall, schist N. 28° E., dip 75° E., and here a fault, the limestone adjoining being nearly horizontal. Between Pine Plains and Stissingville, much of the limestone nearly horizontal, with small eastward dip, varying to westerly. At Stissingville near railroad, limestone N. 12° to 17° E., dip 40°–45° W., and schist near by, N. 12° E., same dip; one mile E. of station, dip 30° E. At Ancram Lead Mine, limestone N. 19° E., dip 60°–70° E.; 3 m. north, limestone N. 19° E., 50°–60° E.; in Copake, 1 m. south of village, limestone N. 13°–16° E., dip 40° E.; near Copake Iron Furnace, schist of Taconic Mtn., N. 10°–15° E., dip 50° E. (average); 3 m. S. of Furnace, adjoining Taconic Mtn., limestone and schist N. 15° E., dip 50° E.

2. *Shekomeko Limestone area.*—The area occupies the valley between Husted station and Pulver's Corners. Thence it extends south-southeast, widening, and ends half a mile south of where the road from Bangall enters the valley. In a cut just northeast of Husted station, limestone N. 25° E., dip 35° E.; schist in next cut, 400 yards to the northeast, N. 25° E., dip 40°–50° E.; 300 yards farther northeast, N. 14° E., dip 50°–60° E.; 1 m. eastward, schist of Winchell's Mtn., N. 16° E., dip 48° E.; on the mountain, 250 yards W. of Winchell's station, schist N. 16° E., dip 20°–60° E., average 40°. Nearly three miles S. of Husted's, just below Shekomeko station, limestone, N. 32°–37° E., dip 50°–60° E.; toward western limit of limestone area, an intercalated stratum of schist, N. 35° E., dip 50°–60° E.; west of this schist, limestone with same position; ¼ m. S. of Shekomeko station, limestone N. 27°–37° E., dip 15°–50° E. W. of south end of the limestone area, slate, near road to Bangall, N. 20°–32° E., dip in undulations, 10°–50° W., but ½ m. to the west, it is 40°–50° E.

3. *Fishkill-and-Millerton belt,* commencing at the southwest.—At Matteawan depot, argillaceous schist on railroad, N. 40° E., dip 70° to 80° E.—a fine-grained, fissile rock, of little luster, fusing B. B. to a slightly magnetic globule, and hence probably an argillitic mica or hydromica schist; ½ m. S.E. of Matteawan, at junction of schist and limestone, N. 52° E., dip 70° E.; ½ m. N.E. of Matteawan, limestone N. 42° E., 70°–80° E.; half way to Glenham (or 1 m. from Matteawan), limestone N. 47° E., vertical; ¾ m. southwest from Glenham, N. 52° E., 60° W.; again ½ m. from G., N. 47° E., 45°–50° W.; in Glenham, on river, limestone and "bastard granite" making parallel walls on opposite sides of the stream, strike of each, N. 37° E., dip 70°–80° E., and south of river, near mill-dam, limestone N. 52°–57° E., dip 35° W., north of river 300 yards, schist N. 22° E., dip 60°–70° E., with "bastard granite" near by to north much jointed and uncer-

tain in strike, becoming near the slate a gray quartzytic variety; north of Glenham station, on river, limestone N. 52°–62° E., dip 25° W. East of Fishkill station ½ m., limestone N. 52° E. (average), dip 55°–60° W. Between this and Brinkerhoff station, ⅛ m. from B., wide variations in strike and dip of limestone, N. 28° W., and even 55° W. to N. 12° E., dip 20°–35° E.; E. of B., ½ m., limestone N. 16° E., dip 50° E.; 1 m., same N. 2°–14° E., 50°–60° E.; 1¼ m. W. of Hopewell, limestone N. 40° E., dip 60° E. One mile southeast of Poughquag, 200 yards west of quartzyte, limestone N. 32° E., dip 40° W.; ½ m. S. of P., limestone N. 32° E., dip 40° E.; ½ m. W. of P., N. 37° E., 40°–50° E.; at Beekman's 1½ m. W. of P., limestone N. 22° E., dip 40°–50° E.; 3½ m. W. of P., north of Silver Lake, an intercalated stratum of contorted schist, N. 22° E., dip 65° E.; and west of this, beyond another limestone stratum, schist N. 12°–22° E., dip 50° E., but contorted; at Arthursburg, schist and limestone N. 12°–22° E., dip 50° E., but with undulations. At Clove Ore bed, limestone N. 37° E., dip E. 45°; schist of west slope of the mountain between Clove and S. Dover N. 52° to 60° E., dip E. varying in 1 m., eastward to N. 37° E., then on descent toward S. Dover, N. 22°–37° E. Nearly ¾ m. N.E. of Mabbitsville, schist contorted, N. 5° W. to N. 2° E., dip 50°–60° E.; 1 m. N.E., impure limestone, N. 6° W., dip 40°–50° E.; schist 2 m. W. of Wassaic N. 22° E., dip varying, 25°–30° E., to nearly horizontal; near Wassaic, schist N. 17°–22° E., dip 60°–70°; 2½ m. W. of Mabbitsville, at Millbrook, schist N. 19° E., dip 70° E. At Millerton, limestone in village, near upper railroad depot, nearly horizontal, dipping 10° to 20° E., strike about N. 12° E.; ½ to 1½ m. west of Millerton, along R.R., N. 10°–20° E., dip 5°–20° E., to horizontal, and 5°–10° W.; 2 m. west of M., on R. R., another large bed of limestone; ⅛ to ½ m. W. of M., schist (a thin, slivery, blackish slate) overlying the limestone nearly horizontally (as seen in section on the west); 1½ m. to 2 m. north of west of M., on R. R., the same schist, nearly horizontal over the limestone (as seen in section); 2½ to 3 m. northwest of M., along R.R., schist of Winchell's Mountain N. 20°–28° E. dip, 20°–50° E., the least on the east. Two and one-half m. south of Boston Corners, schist of eastern base of Winchell's Mtn., N. 12°–17° E., dip 20°–25° E., increasing to 45° nearer B. C.; schist of the body of the Mtn., N. 12°–18° E., dip 45° E.; at Boston Corners, close to Taconic Mtn., limestone and schist N. 13°–14° E., dip 70° E. At Weed's Ore Pit, in Southern Copake, 3 m. N. of B. C., schist N. 18° E., dip 62°–65° E.; and 1 m. W., limestone N. 12°–14° E., dip 50°–60° E.

At Verbank, slate N. 5° W. to 12° E., dip 50°–70° E.; limestone conformable to the slate, but much contorted.

The diversity in the strike near Brinckerhoff was probably caused by the spur of Archæan rocks, which reaches from the south nearly to the place. The schist west of Millerton has much luster in Winchell's Mountain, but very little farther east *where the beds are approximately horizontal.*

The quartzyte near Matteawan (see p. 385 of last volume) is situated *directly east* of this place, and extends along for half a mile.

Great Central Belt, commencing at the North.—In North Salisbury, Conn., ½ m. south of Massachusetts boundary, just east of the road nearest to the foot of the mountain, limestone N. 10°–12° E., dip 50°–60° W.; 1 m. to 2 m. farther south, N. 6°–12° E., dip 45°–60° W.; ½ m. east of the first of these loc., dip 50° E.; and 1½ m. E., N. 15°–25° E., dip 50°–55° E.; at head of Wash-nee lake, limestone N. 16° E., dip 45°–55° E.; ½ m. S., N. 3° E., dip 40°–50° E.; at Chapinville, limestone N. 9° W., dip 20°–25° E.; 2 m. N. of Salisbury, mica schist, N. 15° E., 50°–60° E. In Lakeville, on lake, limestone N. 23° W., dip 50° E., and east of lake, limestone N. 18°–23° W., dip 20°–25° E.; 2½ m. east of Millerton, mica schist N. 8°–22° W., dip mostly 40° E.

In Sharon, ½ m. E. of Sharon Post Office, limestone N. 20° E. (average) dip 60° E.; 1½ m. to southeastward, gneiss, N. 26° E., dip E.; 2 m. to southward of Sharon, *quartzyte*, N. 26°–31° E., dip 60° E., the quartzyte in part schistose and containing some silvery mica, in other parts to eastward feldspathic and passing into granulyte, and the quartzyte and gneiss lying conformably along the east border of the limestone.

East of Wassaic, N. Y., limestone N. 12°–22° E., dip 45°–50° E.; 1½ m. S., limestone N. 26°–27° E., dip 55° E.; east of last, *quartzyte* (at quarry) N. 4° W., 40°–45° W. East of Dover Plains, 1 m., limestone N. 10°–20° E., dip 50°–60° E.; ½ m. farther east, and just east of the limestone area, quartzyte N. 10°–21° E., dip 50°–60° E.; ⅛ m. S.E., gneiss N. 10°–11° E., dip same. At South Dover, near R. R. station, limestone N. 20° E., dip 70°–80° E.; one mile north of Pawling, limestone N. 7° E., dip 70° E.; 1 m. E. of same, gneiss and mica schist N. 7° E., dip 70°–80° E., near Pawling Station, limestone N. 19° E., dip 60°–70° E.; and ½ m. to 1 m. W., same N. 2° E., dip 40°–70° E.; then nearly horizontal with dip westward and again eastward, and then 40°–50° E. prevails; 2 m. W., gneissoid mica schist or micaceous gneiss (just W. of a limonite ore bed) N. 2°–10° E., and varying to N. 32° E., dip 50° E. About Towner's (near the Archæan), gneiss underlying conformably the limestone, with wide variations in strike, N. 68° W., dip 40° E., but in hill to W., N. 38° W. to N. 88° W., dip E., about 40°; 1 m. S. of T., in the marshy valley, near a red house, the limestone interstratified with the gneiss, N. 32° E., dip 60° E. (the vicinity of the Archæan accounts for the contortions); ¼ m. N. of Dykeman's, whitish gneiss, N. 17° E., dip 70°–80° E.

The limestones of Dutchess County are distinctly fossiliferous only where, besides being imperfectly metamorphic, they do not contain seams of quartz, but instead calcareous seams, if any, as well as calcareous fossils. The quartz seams imply greater heat for the metamorphism; and when the penetrating moisture was thus rendered siliceous, the shells have been left as thin pieces of quartz, usually with little of the original form. The schist adjoining also has often its quartz seams or veins.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Action of Isomorphous salts in exciting the Crystallization of Supersaturated Solutions of each other.*—**THOMPSON** has studied the action of solid salts upon supersaturated solutions of other salts, isomorphous with these, to ascertain whether crystallization would be induced. When the salt used as the nucleus, as well as the other, formed a supersaturated solution, such a solution of the latter was placed in a small flask and a corresponding solution of the former, placed in a thin bulb tube was introduced into the flask, the liquid having been boiled and the mouth closed with cotton. The liquid in the flask was then boiled and its mouth was also stopped with cotton. After cooling, the liquid in the bulb tube was first caused to crystallize by a fragment of the same salt. It was then lowered into the liquid in the flask, and broken and the result observed. If the liquid in the bulb was not a supersaturated solution, it was allowed to crystallize on cooling before the bulb was broken. Another method was to use in place of the bulb, a doubly bent syphon tube containing the exciting liquid. In some cases a thoroughly washed nucleus was dropped into the supersaturated solution. The results showed that $MgSO_4\ (H_2O)_7$ was made to crystallize by the corresponding sulphates of zinc, nickel, cobalt, iron and magnesium, by $NiSO_4(H_2O)_6$, $FeSO_4(H_2O)_7$, and $CoSO_4(H_2O)_7$; while $MgK_2(SO_4)_2(H_2O)_6$, $Na_2SO_4(H_2O)_{10}$, $Na_2S_2O_3(H_2O)_5$, NaCl and glass had no action. $Na_2SO_4(H_2O)_{10}$ was made to crystallize by $Na_2SeO_4(H_2O)_{10}$ and $Na_2CrO_4(H_2O)_{10}$, but not by $MgSO_4(H_2O)_7$, Na_2SeO_4, $Na_2S_2O_3(H_3O)_5$, $Na_2HPO_4(H_2O)_{10}$, KCl, NaCl, $KClO_3$, $NaI(H_2O)_4$ or glass. Chrome and iron alums caused potassium aluminum alum to crystallize, while NaCl, FeS_2 (in cubes) and Fe_3O_4 (in octahedrons) did not. In the case of mixtures there are two cases: A, when the mixture contains two salts which are not isomorphous; and B, when the two salts are isomorphous. In the former case, (*a*) sudden crystallization takes place with a deposit only of the salt forming the nucleus; (*b*) the same, both salts being deposited but the one like the nucleus preponderating; and (*c*) the nucleus may slowly grow by accretion of its own salts from the solution. In the latter, (*a*) sudden crystallization takes place, both salts being deposited apparently in the ratio in which they exist in the solution; and (*b*) slow crystallization goes on, the least soluble salt being deposited. This latter case shows that there is a regular gradation from supersaturated to ordinary crystallization.—*J. Chem. Soc.*, xxxv, 196, May, 1879. G. F. B.

2. *On Ozone and the Silent Electric Discharge.*—**BERTHELOT** has observed some curious anomalies in the action of the silent electric discharge itself or of the ozone which it produces, upon chemical combination. Hydrogen and oxygen, for example,

mixed in the proportion of 2 : 1, do not combine under these circumstances even when submitted to the action of the silent discharge for several hours, with a spark in ordinary air of 7 or 8 cm. This result is the more remarkable, since oxygen under these conditions combines readily with the metals, sulphurous oxide, arsenous oxide, iodine, and even nitrogen. Carbonous oxide on the other hand, mixed with half its volume of oxygen, left after twelve hours only eight per cent uncombined, mixed with two per cent of oxygen; the rest having united with the mercury. A part of the CO had formed a brown oxide C_2O_3. Carbon dioxide under the action of the silent discharge, in a space free from oxidable bodies gives results which lead the author to suspect the existence of a percarbonic oxide CO_3. In one experiment, after twelve hours, sixteen per cent of the CO_2 was decomposed, and a gas was formed which attacked mercury and oxidable bodies with vigor. This cannot be ozone since in that case from thirty to forty-one per cent of the oxygen set free would have been converted into this substance, an unheard of proportion. The new body has not been isolated.—*Ann. Chim. Phys.*, V, xvii, 142, May, 1849. G. F. B.

3. *On the Occlusion of Hydrogen by Copper.*—JOHNSON has re-examined the result deduced by him from his earlier experiments, that metallic copper occluded an amount of hydrogen which might cause serious error in organic analysis; this result having been questioned by Thudichum. The copper to be tested was oxidized at the blowpipe, reduced in hydrogen, allowed to cool in that gas, the H displaced from the tube by dry air, the metal re-oxidized in a current of dry air, the water produced being collected in a weighed tube containing pumice moistened with sulphuric acid, special precautions being taken to exclude extraneous moisture. It was found that this occlusion actually took place, and that the pulverulent metal formed from the oxide reduced on the surface of the copper was most active, the amount occluded diminishing progressively as the metallic powder becomes denser by successive heating. A carefully conducted experiment showed the occlusion of 0·035 gram of hydrogen by 100 grams of copper. But curiously enough, it appeared that the finest precipitated copper oxide yields a finely divided metal on reduction, which does not occlude hydrogen. Moreover the author found that the copper thus hydrogenized, reduced potassium chlorate to chloride, and when ignited in CO_2 reduced it to CO. Heated in CO or in N, all its occluded hydrogen is given up. Heating alone in a vacuum does not set free the gas. The author therefore concludes that it is unsafe to employ copper freshly reduced in hydrogen for the reduction of oxides of nitrogen in organic analysis unless the metal be previously ignited in nitrogen gas.—*J. Chem. Soc.*, xxxv, 232, May, 1879. G. F. B.

4. *On the Composition of Charcoal from pure Cellulose.*—BERTHELOT has examined the charcoal produced from the pith of the spindle tree (*Euonymus*) in the process of carbonizing this

word for the manufacture of gunpowder. This charcoal therefore was made out of contact with the air and with the pyrogenic reaction products. After drying at 100°, during which it lost nine per cent, it was burned in a current of oxygen, and left 3·5 per cent of ash. The combustion afforded: carbon 73·6, hydrogen 2·2, potassium 2·1, oxygen 21·8, giving the formula $C_{124}H_{43}KO_{27}$; though no formula is actually probable of course. This charcoal contains oxygen much in excess of that which a simple hydrate of carbon requires, its amount being surprising. This is one of those special compounds of high molecular weight formed by successive condensations, carbon itself being the limit which is finally reached.—*Ann. Chim. Phys.*, V, xvii, 139, May, 1879. G. F. B.

5. *On the Substitution derivatives of Nitrogen trichloride.*—**Köhler** has investigated the bodies discovered by Wurtz and considered by him derivatives of nitrogen trichloride. Tschermak first established the correctness of this supposition by acting on dichlorethylamine with zinc-ethyl and obtaining triethylamine. The author has confirmed these results and has produced the corresponding methyl compound, dichlormethylamine $N.CH_3.Cl.Cl$. It is a gold-yellow liquid, irritating to the eyes, boiling between 59° and 60°, and quite permanent. Köhler hopes by its means to produce the azo-compounds of the fatty series, by a reaction analogous to that by which phosphobenzene is produced from phosphenyl chloride and phenylphosphine.—*Ber. Berl. Chem. Ges.*, xii, 770, May, 1879. G. F. B.

6. *On the Preparation of pure Cuprous chloride.*—The difficulties in the preparation of pure, dry and white cuprous chloride are well known. **Rosenfeld** having observed that the oxidation product of this body is converted into copper acetate by glacial acetic acid, while the cuprous chloride itself is only difficultly soluble in this liquid, has suggested a new method of preparation. By passing SO_2 gas into a mixture of equal molecules salt and copper sulphate in solution, the cuprous chloride is precipitated. This is collected on a vacuum filter, and washed first with SO_2 solution till this comes through colorless, and then with glacial acetic acid till the product appears perfectly white. The acid is drawn out of the precipitate by the vacuum, and this is pressed between paper and dried on the water bath, or in the air at ordinary temperatures. Thus made, it is a pure white powder composed of colorless tetrahedrons upon which strong sunlight has no action. Strong sulphuric acid scarcely acts on it. In the dark, dilute nitric acid is also without action; but when suspended in nitric acid diluted with six parts of water, the cuprous chloride is extraordinarily sensitive to light, the crystals becoming black with a luster like metallic copper, and suffering a true reduction.—*Ber. Berl. Chem. Ges.*, xii, 954, May, 1879. G. F. B.

7. *On the Composition of Wood.*—**Thomsen**, noticing the considerable quantity of extract yielded to dilute sodium hydrate solution by birch wood, which extract was precipitated again

either on neutralizing with an acid or on the addition of alcohol, has made a systematic examination of the substance thus obtained. For this purpose sawdust from birch wood was treated with soda solution of 1·1 sp. gr. for 24 hours, diluted and filtered. The brown solution on saturation with H_2SO_4 deposited a whitish gelatinous precipitate. Alcohol acted similarly but the filtration was easier. After washing with alcohol and drying at 100°, it constituted fifteen per cent of the wood used. As it acts like a gum the author proposes to call it wood-gum. Subsequently a purer product was obtained by previously treating the wood with ammonia, and then with the soda. It afforded on analysis carbon 44·6, hydrogen 6·4, corresponding to the formula $C_6H_{10}O_5$. Comparative examinations of the quantity of this substance in various woods were then made, and the kinds examined by the sulphuric acid method arranged themselves in the following order in this respect: birch, ash, alder, cherry, white beech, oak, pear, beech, elm, willow, horse-chestnut, maple and pine, the last yielding only traces. The quantity was greater the nearer to the center of the tree the specimen was taken. Wood-gum is insoluble in cold water, but dissolves in fifty parts of boiling water, gelatinizing on cooling. It does not ferment after boiling with dilute sulphuric acid, does not reduce the copper test, and rotates to the left.—*J. prakt. Ch.*, II, xix, 146, March, 1879. G. F. B.

8. *Dust Figures produced by Sound Waves.*—Her. K. H. SHELLBACH and E. E. BOEHM extend the work of Professors E. Mach and Fischer on the reflexion and refraction of sound contained in Pogg. Ann., cxlix, p. 421, 1873. By the use of fine coal dust strewn upon paper they were enabled to trace the effect of sound waves. When the prepared paper was placed beneath the spark produced by a Holtz machine, provided with large condensers, concentric rings appeared which were due to the sound waves. When the spark was produced between converging planes the waves of reflection of sound were clearly evident upon the prepared paper. The various theoretical laws in relation to caustics by reflection from spherical surfaces; the reflection from one focus of an ellipse to the other and the principle of Huggens in regard to the reflection of waves of light were distinctly shown to hold good experimentally in the case of sound. These experiments are analogous to those of Toppler, published many years ago. The latter physicist, however, gives a much more interesting way of studying sound waves by actually illuminating, so to speak, the wave itself.—*Annalen der Physik und Chemie*, No. 5, 1879, p. 1. J. T.

9. *Continuous Spectrum of Electric Sparks.*—Professor ANTON ABT shows that the spectrum of the electric spark between two conductors in water and other fluids is a continuous one, and does not contain the lines which are apparent in the spectrum taken between metallic conductors in air. He attributes the continuous spectrum to the particles of the metals of the electrodes which are raised to a white heat but not to the gaseous condition which pro-

duces bands, when the spectrum of the spark in air is perceived.—*Annalen der Physik und Chemie*, No. 5, 1879, p. 159. J. T.

10. *A New Theory of Terrestrial Magnetism.* — Professors **Perry** and **Ayrton** have proposed the following theory of terrestrial magnetism, which is based upon the experiments of Professor Rowland, of Johns Hopkins University, Baltimore, carried out in Professor Helmholtz's laboratory. In these experiments Professor Rowland showed that a magnetic needle is deflected by the movement of a static charge of electricity. Professor Rowland detailed to the writer of this notice, two years ago, in Cambridge, the same theory which is now proposed by Professors Perry and Ayrton. The theory is that the revolution of the earth beneath the electrical charge originally and at all times present in the atmosphere may and is sufficient to account for the magnetism of the earth.

Professors Perry and Ayrton have submitted the matter to calculation, and find that the difference of potential between the earth and space necessary to produce a distribution sufficient to produce the observed magnetic effect can be represented by fifty-four million Daniell cells.. They prove, according to this theory that "if the earth be electrified, it must, from its very rotation, quite independently of all other bodies in the universe, be magnetic; and if it consist of a shell of iron, thick or thin, then that the law of distribution of magnetism produced by this electrical charge in mechanical rotation, will be identically that given by Biot; and, lastly, if the earth were wholly of iron, a difference of potentials of about fifty-four million volts between it and space would be sufficient to produce the necessary amount of charge.—*Phil. Mag.*, No. 45, p. 401, June, 1879. J. T.

11. *Experimental researches in Pure, Applied and Physical Chemistry;* by E. **Frankland**, Ph.D., D.C.L., F.R.S., &c. 1047 pp. 8vo. London, 1877. (John Van Voorst).—Dr. Frankland has made a most acceptable gift to chemical literature and especially to the convenience of students, by bringing into one volume his numerous memoirs, extending over thirty years and scattered in various Journals and Transactions. The sixty-four memoirs here reproduced are pretty equally divided between pure, applied and physical chemistry. The rapid and fundamental changes in chemical philosophy and notation, which have occurred during the period covered by Dr. Frankland's memoirs, changes toward which his own researches have largely contributed, have required a thorough revision of the notation of his earlier papers. The volume opens well therefore with a reproduction of his "Contributions to the Notation of Organic and Inorganic Compounds" from the Journal of the Chemical Society (1866). The nine chapters devoted to pure chemistry contain some of the most important researches which mark the progress of discovery in organic chemistry. For example, the three memoirs on the "Isolation of the Alcohol Radicals," the nine memoirs on the "Synthesis of Organo-metallic bodies," the two synthetical researches on acids of the

lactic series, one on the acids of the acrylic series, and four on fatty acids. Each of these series of researches forms a continuous work and is prefaced by an analytical *resumée*, prepared for this volume, giving the author's mature views on reviewing the several subjects in the light of our present knowledge.

The experimental researches on various subjects in applied chemistry are full of interest; they include among the subjects, artificial light; the so-called hydro-carbon gas process; the gas supplied to London in 1851 and 1876; contributions to the knowledge of the manufacture of gas; on the igniting point of coal gas; and on magnesium as a source of light; all of which are replete with valuable data both theoretical and practical. The chapter on drinking water embraces, in six memoirs, a mass of valuable original research, as also does that on the purification of foul water, discussed in five memoirs. Every student of public hygiene as well as chemists will profit by the study of these chapters.

The memoirs on the influence of atmospheric pressure on combustion, and on the spectra of gases and vapors form the opening chapters in the section on Physical Chemistry, which is continued in memoirs on the source of muscular power and on climate.

Authors like Graham and Frankland (and we may add Rumford, whose collected memoirs the American Academy at Boston have lately made accessible) promote the progress of science not alone by the actual work done by them in original research, but possibly quite as much by the unconscious influence such collected memoirs exert by furnishing models of investigation worthy of imitation and stimulating others to a generous rivalry. B. S.

12. *A Guide to the Qualitative and Quantitative Analysis of the Urine, &c.;* by Drs. NEUBAUER and VOGEL, with a Preface by Professor FRESENIUS; translated from the seventh enlarged and revised German edition by Dr. Elbridge G. Cutler of Massachusetts General Hospital and assistant in the Medical School of Harvard University. Revised by Dr. Edward S. Wood, Professor of Chemistry in the Medical School of Harvard University. 551 pp. 8vo. New York, 1879. (William Wood & Co.).—A new translation of Neubauer and Vogel's well known work, which, since 1854, has passed through seven editions (to 1875) in the German, is a welcome and important contribution to the study of this special department of Chemistry. The translation of this work published by the Sydenham Society in 1863 was from the third edition, since which time very important changes in the text with numerous additions have rendered a new translation essential. No other work in the English language treats this department of chemistry in so systematic and thorough a manner, and it is risking little to say that this translation will come into general use wherever medical chemistry is taught as well as among chemists and physicians whose investigations demand a knowledge of the best methods of analysis and pathology in this direction. B. S.

13. C. GREVILLE WILLIAMS, F.R.S., of London, has just added a *Supplement to his Hand-book of Chemical Manipulation.* 88 pp.

8vo. London, 1879. (Van Voorst.)—This handbook, well known to chemists, contains notices of new methods of manipulation, with twenty-three figures of apparatus adapted for improved laboratory practice, and mostly selected from contemporary literature, with some things not before published. The selection is generally judicious and the supplement will be found useful in every working laboratory. B. S.

14. *Specific Gravity of the Vapors of Phosphoric Pentasulphide and Indium Chloride.*—VICTOR MEYER and CARL MEYER have determined the specific gravities of these vapors by the method of displacement which they devised and had previously described. They have found, in two determinations for the vapor of phosphoric pentasulphide, the specific gravities 110·1 and 110·7 when $H_2=1$ and for that of indium chloride the value 113·6. As the half molecular weight of P_2S_5 is 111, it is evident that this compound—unlike P_2Cl_5—is converted into vapor without disassociation; and since the specific gravity of the vapor of indium chloride corresponds very closely to that required for $InCl_3$, it would appear that this compound ought not to be classed with the sesquichlorides Fe_2Cl_6 and Al_2Cl_6, as chemists have been inclined to place it since the investigations of Bunsen on the specific heat of indium.—*Ber. der Deutsch Chem. Gesellsch.*, 28 April, 1879, p. 609.

II. GEOLOGY AND NATURAL HISTORY.

1. *Die Dolomit-Riffe von Südtirol und Venetien. Beiträge zur Bildungsgeschichte der Alpen*, von E. MOJSISOVICS VON MOJSVÁR. 552 pp. 8vo. Vienna, 1878. (Alfred Hölder.)—The Dolomite region of the Southern Tyrol is well known as one of the most remarkable portions of the Alps, both in the unique beauty of its scenery, and in the variety and interest of its geological structure. The strangely picturesque and wonderfully varied forms of the dolomite mountains, sometimes in perpendicular walls, and again as sharp jagged peaks, give the region a striking character of its own. Moreover, the peculiar interest connected with the study of them, as also that of the accompanying igneous rocks and the contact phenomena involved with them, has long made it a favorite region for geological study.

The present work gives a clear, comprehensive, and, at the same time, minute description of the geological relations of the whole region by one whose long experience in the study of the Eastern Alps has thoroughly fitted him for his work. In addition to the special description of each section of the country, with the numerous cuts and profile views, the work also includes several chapters of more general interest, and one of these contains a discussion of the Permian and Mesozoic Formations of the Eastern Alps. The closing chapters give the author's views in regard to the method of formation and time of elevation of the Dolomite peaks. He adopts the view, first put out by Richthofen in 1860, that the dolomite mountains are true *coral reefs*, and finds confirmation for it in the massive unstratified character of the rock, and the fact that while poor in fossils they yet contain more corals than any other form of organic remains.

The work is accompanied by a large and finely executed geological chart in six sheets, and is moreover illustrated by thirty photo-engravings (Albertypes) which give an admirable idea of the most striking and beautiful features of the country, and are of great service in making clear the geological descriptions. E. S. D.

2. *A Native gelatinous Silicate.*—Prof. E. Renevier has described the occurrence of a gelatinous silicate, having the composition of chabazite. It was found in small fissures in the molasse, near Lausanne, Switzerland, on the occasion of the building of a tunnel. When first taken out it was in a gelatinous state, like semi-liquid starch paste. Its color was white, translucent, its luster was greasy, and the touch unctuous. In the air it dried rapidly, and at the end of some weeks it was transformed into a soft, white, sectile mass, having some consistency, and more or less plastic. If exposed still longer it became nearly solid, resembling steatite; in this condition it had about the hardness of talc, and its specific gravity was found to be 2·08—2·10. An analysis by Prof. Bischoff, on material dried at 100° C., afforded the following results:—

SiO_2	$\bar{A}lO_3$	CaO	MgO	K_2O	H_2O
48·39	20·49	3·57	3·14	2·79	21·62=100·00

This corresponds closely with the composition of chabazite, and Renevier refers it to this species, but calls it a "mineral in an embryonic condition."—*Bull. Soc. Vaud. Sc. Nat.*, xvi, 81. E. S. D.

3. *Naturwissenschaftliche Beiträge zur Kenntniss der Kaukasusländer auf Grund seiner Sammelbeute herausgegeben*, von Dr. OSCAR SCHNEIDER. 160 pp. 8vo, Dresden, 1878.—The extensive collections in natural history, mineralogy and geology, made by Dr. Schneider in the Caucasus during the summer of 1875, have been worked over in part by himself and in part by a number of specialists, and the results are contained in the present volume. The minerals have been studied by Professor Frenzel; among other points he describes a new species under the name of *urusite*. It was found with iron vitriol and other iron salts at Tscheleken. Its characters are as follows: it occurs in rounded masses, also pulverulent and earthy. The lumps are soft and easily crushed to a powder consisting of minute orthorhombic crystals. The specific gravity is 2·22; the color is orange yellow and the streak ochre yellow. An analysis gave: SO_3 42·08, $\bar{F}eO_3$ 21·28, Na_2O 16·50, H_2O 19·80 = 99·66. This corresponds to the formula $Na_4\bar{F}eS_4O_{17}+8H_2O$.

4. *Mémoire sur le Fer Natif du Grœnland et sur la Dolerite qui le renferme* par J. LAWRENCE SMITH. (Annales de Chimie et de Physique, V, xvi, 1879).—The native iron of Ofivak, Greenland, was discovered by Professor Nordenskiöld in 1870, and by him described as of meteoric origin; later writers, however, have

been inclined to refer it to a terrestrial rather than to a cosmical source. This matter has been made the subject of an extended memoir by Dr. Lawrence Smith, and his conclusion that the iron is in fact terrestrial is so thoroughly proved that it can hardly be questioned in future. Dr. Smith describes in detail the several varieties of the iron and gives analyses of them; he has also investigated the dolerite in which the iron occurs both chemically and microscopically, and all the points are discussed with admirable thoroughness. The remarkable disintegration which has reduced many of the seemingly solid masses of iron to a fine powder, Dr. Smith attributes first to the loss of moisture, which results in the production of cracks in the surface, and then to the fact that the air, having access to the interior of the mass and meeting the iron in a finely divided state, rapidly causes its oxidation. An analysis of the unoxidized iron afforded the following results: G. = 6·42

Fe	Ni	Co	Cu	P	S	Cl	C (combined).
93·16	2·01	0·80	0·12	0·32	0·41	0·02	2·34 = 99·18

Other varieties of the iron associated with the dolerite gave somewhat different results, but all showed the presence of both nickel and cobalt. Associated with the iron in the dolerite were the following minerals: niccoliferous pyrrhotite, graphite, hisingerite, magnetite, spinel and corundum. Of these the graphite is the most interesting in relation to the explanation offered by Dr. Smith for this extensive occurrence of native iron. He argues that the basaltic rocks of Northern Greenland at the time of their eruption must have forced their way through lignitic miocene beds, setting free by their heat vast amounts of gaseous hydrocarbons, which would have exerted a powerful reducing effect on the iron oxides in the basalt. This would explain the considerable amount of combined carbon in the iron and also the large amount of graphite present in the rock. Dr. Smith has also reinvestigated some of the other so-called meteoric irons of Greenland, found at various localities for lat. N. 63° to 76°. He concludes that they are all similar to the Ofivak iron, and probably, like it, are of terrestrial origin.

5. *Jarosite (with Gold).*—This rather rare species occurs quite abundantly in the quartz veinstone of the Vulture gold mine in Arizona, whence I have received it from Mr. G. A. Treadwell. It fills cavities formed from the oxidation of pyrite. Fine transparent, yellow and dark brown, rhombic crystals—almost microscopic, are alternated with cryptocrystalline masses, in which, occasionally, are seen small brilliant particles of gold. The Vulture vein is enclosed in walls of a schistose gneiss or mica schist, and the atmospheric decomposition of the sulphide has been so complete that at a depth of nearly 300 feet only cubical cavities and a curious structure due to the removal of pyrite are observed, and the mine at that considerable depth is *completely dry.* B. S.

6. *The Botanical Text-book.* (*Sixth edition.*) *Part I. Structural Botany, or Organography on the basis of Morphology. To*

which is added the Principles of Taxonomy and Phytography, and a Glossary of Botanical Terms; by ASA GRAY, LL.D., etc., Fisher Professor of Natural History (Botany) in Harvard University. 442 pp. 8vo. New York and Chicago. 1879. (Ivison, Blakeman, Taylor and Company.)—The first edition of Dr. Gray's work was published in 1842: the year in which the author entered upon the duties of the Fisher Professorship at Cambridge. Six years before this, however, he had published a work entitled *The Elements of Botany*, which may be fairly regarded as a still earlier edition of the Text-book. The plan of this early work was generous in its scope, and was philosophically developed. A morphological basis was adopted as the only safe one on which to build, and upon this a symmetrical superstructure was erected. It was no ordinary sagacity which led a young botanist, without experience in teaching, to select a method which has needed no essential change for forty years, and which is to-day generally accepted as best adapted to elementary and advanced instruction. The "Text-book," which was developed from the earlier "Elements of Botany," has passed through several editions, the last of which, published in 1852, is widely known under the title, "Structural and Systematic Botany." A still further development of the plan selected at the outset, necessitated a division into separate volumes, and it is of this that mention must now be made. The present edition of the Text-book has outgrown its former limits and is to be embodied in four volumes. The first, devoted to Organography, upon the basis of Morphology, has just been published; the three remaining, to follow after a time, are to comprise respectively, Histology and Physiology, Cryptogamic Botany, Special Morphology of the Natural Orders. Other hands are to aid in preparing the second and third volumes. The arrangement of the early chapters in the present volume is nearly the same as that of former editions, but every section has been rewritten and considerable new matter added. Important changes have been made in the chapter on Inflorescence, or Anthotaxy. For the old names of the two types, the new ones, Botryose and Cymose have been substituted, and the forms of the latter are for the first time in English placed upon the satisfactory basis suggested by Eichler. The terminology of cymose clusters has, until recently, been much neglected, and has given rise to unnecessary confusion. An analytical table of the special kinds of definite, indefinite and mixed inflorescence is given at the end of the chapter, and will be found useful by students.

The sections devoted to the flower have undergone very great modifications. The deviations from the type-flower are discussed more fully than in any former edition, and the adaptive structures are described with considerable minuteness. It would be difficult to find a more succinct exposition of the mechanism of intercrossing than Dr. Gray has given in section IV. The special morphology of the stamens and pistil has been revised throughout and more copiously illustrated. It is instructive to observe how little

Dr. Gray's opinions respecting some mooted points of this subject have changed in the successive editions of the Text-book; in the present issue the author cites with quiet satisfaction the freshly discovered and weighty evidence in support of his early views. He adheres to his well-known belief, now well established, that placentæ belong to carpels and not to the cauline axis. He adopts the theory that ovules answer to leaf-lobes peculiarly transformed, or to outgrowths of a leaf, whether from its edges or surface. Under fruits and seeds, little new matter has been added, except a useful synopsis of simple fruits.

Thus far the work has dealt with Morphology and adaptations: the last part of the volume is devoted to Taxonomy. This presentation of the principles of classification may be fairly considered the most important chapter in the work, and an abstract must be made almost in the author's words. Holding the view that plants do not rise high enough in the scale of being to reach true individuality, the author takes as the analogue of the animal individual, the cell in the lowest grades of vegetable life, the phytomer (*phyton*) in the higher. "In botanical description and classification, by the individual is meant the herb, shrub, or tree, unless otherwise specified." "Species in biological natural history is a chain or series of organisms of which the links or component individuals are parent and offspring." "The two elements of species are: 1, community of origin; and, 2, similarity of the component individuals. But the degree of similarity is extremely variable, and the fact of genetic relationship can seldom be established by observation or historical evidence. It is from the likeness that the naturalist ordinarily decides that such and such individuals belong to one species. Still the likeness is a consequence of the genetic relationship; so that the *latter* is the real foundation of species." Variation within the species is next discussed, and it is shown that only observation can inform us how much difference is compatible with a common origin. The general result of observation is that plants and animals breed true from generation to generation within certain somewhat indeterminate limits of variation: that those individuals which resemble each other within such limits interbreed freely, while those with wider differences do not. Hence are recognized Varieties, or differences within the species, and Genera and other superior associations, in which the differences are more striking. Grades denote degrees of likeness or difference; but what is the explanation of the likeness between species themselves? With the accepted facts respecting variation, crossing and the like, before him, the author adopts the theory of descent and limitation by natural selection, to furnish an answer to the question just asked.

On page 330, the author says, "We have supposed . . . . that each plant has an internal tendency or predisposition to vary in some directions rather than in others; from which, under natural selection, the actual differentiations and adaptations have proceeded. Under this assumption and taken as a working hypothesis, the doctrine of the derivation of species serves well for the coordination of all the facts in botany, and affords a probable and reasonable answer to a long series of questions which, without it, are totally unanswerable." Following this comes a short section on the history of classification, in which is given an outline of the growth of the natural system.

The last chapter is devoted to Phytography. In this are given directions for describing plants in technical language, and for assigning names to new species in conformity with the canons of nomenclature. The fixation and precision of names is dealt with critically and at some length. Upon many points which have been held to be in dispute, the law is pretty authoritatively laid down. The important but too much neglected subject of herborizing and of preparing good dried specimens of flowering plants, is minutely and sensibly treated by Mr. Hoysradt. Directions for the formation and care of an Herbarium, and the study of dried specimens, are both as fully referred to as the space could warrant.

The volume closes with a long list of the signs and the chief abbreviations, including those of authors' names, occurring in systematic treatises. The index is an extensive glossary, in which, for the convenience of many, are given the Latin equivalents of most of the substantives and adjectives employed in botany. From the foregoing it must be seen that the present volume of the work is adapted, as we stated in the outset, to the wants of the advanced student and the working botanist alike.

G. L. G.

7. *Chronological History of Plants: Man's Record of his own existence illustrated through their names, uses, and companionship;* by CHARLES PICKERING, M. D. Boston, 1879. (Little, Brown & Co.)—This is a quarto volume of over twelve hundred closely printed pages, about half of which were already in type before the death of the learned author, which event took place March 17th, 1878. The remainder has been printed by his widow "in exact conformity with the manuscript." The work is arranged chronologically, and begins with the year 4713 B. C., the so-called Julian Period, followed immediately by 4491 B. C., the beginning of the first Great Year in the Egyptian reckoning. The first plant mentioned by Dr. Pickering is *Artemisia Judaica* of the desert of Sinai, which he considers to be the plant of the field of Genesis ii, 5, and the second is the tree which yields bdellium, probably a palm, *Borassus dichotomus*, though possibly a species of *Balsamodendron.* The remaining plants, animals, musical instruments and metals of the antediluvians are next considered, and then, with the year 4000, Jan. 1st, the ninth generation, he passes to the colonization of Egypt, and gives first a systematic list of the plants composing the Desert Flora, and then a similar list of the maritime Mediterranean Flora. Next follow forty-six pages devoted to Egyptian hieroglyphic signs, many of them primarily significant of natural objects. Other parts of the world, with the names of kings, writers, animals, plants and arts follow

year by year, or generation after generation, nearly everything spoken of being explained or interpreted by the author, until, turning page after page, we do not know which to wonder at more, his vast range of knowledge or his patience.

Had he lived he would doubtless have written his own Preface or Introduction, and in it have drawn his own general conclusions from so vast an array of facts. As it is, the work will remain, as Rev. Mr. Morrison says, a vast storehouse, from which other writers may draw the treasures with which they may enlighten their readers, or delight mankind. D. C. E.

III. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Fall of a Meteorite on the* 10*th of May, in Iowa;* letter from Professor S. F. PECKHAM to the editors, dated Minneapolis, May 29, 1879.—I have the pleasure of informing you that on the 10th of May, a meteor exploded and fell in full daylight at 5 P. M., at Esterville, Emmet County, Iowa. One of the fragments, weighing about 500 pounds, fell on railroad land and was dug up from a depth of fourteen feet in a stiff clay soil. Another smaller portion, weighing about 170 pounds, fell on the farm of A. A. Pingrey at a distance of two miles from the first. Many smaller pieces, of a few ounces or pounds weight, were scattered in the vicinity. The smaller mass fell upon a dry knoll and penetrated the earth vertically to a depth of 4½ feet. The fall was accompanied by a noise described as a continuous roll of thunder accompanied by a crackling sound.

Through the efforts of Professor E. J. Thompson of our Faculty the smaller mass has been obtained for the University cabinet. It is irregularly square in form, about 15 × 18 inches and of an average thickness of six inches.

A preliminary chemical examination shows the metallic portion to consist of an alloy of iron, nickel and tin. Full half the mass consists of stony matter, which appears in dark-green crystalline masses embedded in a light-gray matrix. When the whole is powdered, a violent reaction ensues on the addition of hydrochloric acid, which is increased on boiling. The boiling acid appeared to dissolve all but the gray matrix, abundance of iron passing into solution. Some of the crystalline masses are two inches in thickness, and exhibit distinct monoclinic cleavage. Under the microscope in thin sections, olivine, and a triclinic feldspar appear to be imbedded in a matrix of pyroxene. This work is in the hands of Professor C. W. Hall of the University who intends to make a very thorough investigation of the optical properties of the minerals and matrix.

The chemical examination was first attempted upon a very small quantity of material, but, now that we have an ample quantity, a complete analysis of the several minerals and the alloy will be made. A small piece of the metal polished and etched exhibited the Widmanstättian figures very finely.

The larger mass is still in the hands of those who dug it from the ground, although their ownership is contested by one who claims to have contracted for the land on which it fell. Their ideas regarding its value enlarge daily, the latest announcement being, that they should feel insulted at an offer of $5,000. We trust their feelings may be spared.

2. *The supposed Meteorite of Chicago;* from a letter to the editors from Professor E. S. Bastin, dated Chicago, May 23, 1879.— * * * I have concluded that what was claimed to be a meteorite could not have been anything of the kind. A heavy shower was in progress at the time (April 9th), accompanied by thunder and lightning, and according to all accounts at the very moment the fragments of the supposed meteorite were seen to fall, there was a vivid flash and a loud report like that of a heavy stroke of lightning. The telephone wires in a dwelling house that stood only a few yards from the place where most of the glowing fragments were seen to fall, were melted as if by lightning, and more or less disturbance was caused in other wires and telephones about the neighborhood. It is reasonable, I think, to conclude that the glowing fragments that were seen to fall to the side-walk and to rebound from the roofs of buildings were fragments of the melted wires heated to incandescence. The fragments that were picked up that evening and the next morning and were claimed to be portions of the meteorite, do not resemble any meteoric matter I have ever seen. They look very like the slag from an iron furnace, and many fragments very similar to them in appearance may be picked up almost anywhere on our streets. A chemical examination of the specimens has shown that they possess none of the characters of true meteorites.

3. *Nordenskiöld's Swedish Arctic Expedition.* —The latest advices from Stockholm (about May 30th) indicate that telegraphic information had been received from Siberia to the effect that the Vega was in winter quarters in the vicinity of Cape Serdze-Kamen (Heart-of-Stone) in about lat. 67° N. and lon. 172° W. Letters had not been received, but were expected, being on their way from Irkutsk, and were said to be of the (latest) date of February 8th, in which the professor expressed a hope to be released by the ice in May. It is hardly likely that the opportunity will occur before July, since all previous experience shows the straits to be closed or impeded up to a date between the 1st and 15th of July, and often somewhat later. The position of the party is one which is free from ice every year, and there is little doubt but that the Professor will be able to carry out his idea of circumnavigating Europe and Asia in the Vega. The party at the date of writing were all well, and the letters had reached Yakutsk *via* Kolymsk by the hands of traveling natives.

WM. H. DALL.

4. *Eruption of Etna.*—The new eruption began on the 25th of May, and on the 28th, after two days of ejections of fiery cinders making clouds and rain of volcanic ashes of great extent,

the lava was seen flowing toward Randazzo. The new craters are situated near Monte Nero, 6,232 feet above the sea, and a fissure has been opened on that side (the northwest) of the mountain. The lavas have devastated the wood of Collebasso, destroyed the vineyards, and also a bridge across the Passo Pischiaro. The rate of flow on the 30th was one meter per minute. According to reports the stream has nearly reached Alcantara.—*Nature*, June 12.

5. *Influence of Coal-dust in Colliery Explosions.*—An investigation, by W. Galloway, communicated to the Royal Society, on experiments as to the influence of coal-dust in colliery explosions, has led to the conclusion that: "Although the apparatus employed appears to be on too small a scale to solve the coal-dust question unequivocally, the results obtained with it appear to be sufficiently conclusive to enable us to affirm that an explosion, occurring in a dry mine, is liable to be indefinitely extended by the mixture of air and coal-dust, produced by the disturbance which it initiates. The only means of avoiding the dangers due to the presence of coal-dust in mines appears to be to carefully and constantly water the road-ways leading to and from the working places."

6. *Elephant Remains of Southwestern part of Washington Territory.*—Mr. J. T. Donald, describes in the Canadian Naturalist, vol. ix, no. 1, the discovery of a collection of bones, over 300, in a bog, twelve feet below the surface. They are referred to *Elephas primigenius*, var. *Jacksoni* (*E. Jacksoni* of Briggs and Foster).

7. "*On the Cudgegong Diamond-field, New South Wales.*" By Norman Taylor.—The diamonds of this locality occur in river-drift, associated with gold and other gems. The drifts in the district are at least six in number. The oldest is considered by the author to be Upper Miocene or Lower Pliocene; the next middle Pliocene; others Upper Pliocene, Pleistocene, and Recent. Between the Middle and Upper Pliocene flows of basalt lava took place which have sealed up much of the older drifts. Diamonds are found in the oldest drift and, probably by derivation from it, in the newer. Gold, metallic iron, wood, tin, brookite (?), iron-sand, quartz, tourmaline, garnet, pleonast, zircon, topaz, sapphire, ruby, and corundum are also found. The author then considers the question of whether the diamonds are derived from some of the igneous or sedimentary formations (from Upper Silurian to Mesozoic) which have contributed to the drift; and concludes, from a variety of reasons, that the diamonds have been formed *in situ* in the older drift.—*Phil. Mag., June, p.* 442, 1879.

8. *Report of the New York State Survey for the year* 1878, James T. Gardner, Director.—The third annual Report of Mr. Gardner contains a statement of the work accomplished in 1878, and is accompanied by four large maps showing the completed triangulation and its proposed extension during the coming season. The field work has been principally upon the central belt of triangles, which is to extend from Albany to Buffalo. The results

of the Survey thus far have been most important; they have revealed so great a degree of inaccuracy in existing maps of the State, that the completion of the work is seen to be a matter of the highest necessity. It is satisfactory to know that the appropriations for the present year have been already made.

9. *Transactions of the Wisconsin Academy of Sciences, Arts and Letters.* Vol. iv, 1876–77. 320 pp. 8vo. Madison, Wisconsin, 1878 —The papers in the Department of Natural Science here published include the following: Notes on Cladocera, by E. A. Birge; on the Fauna of the Niagara and Upper Silurian rocks of Milwaukee County, Wisconsin, by F. H. Day; on the extent and significance of the Wisconsin Kettle Moraine, by T. C. Chamberlin; and papers on the Mound Builders, by E. Andrews, P. R. Hoy and J. N. de Hart.

10. *Ocean Wonders, a Companion for the Seaside, fully illustrated from living subjects;* by Wm. E. Damon. 230 pp. 12mo, with many illustrations. New York, 1879. (D. Appleton & Co.)—Many facts respecting the productions of the ocean are here presented in an attractive way, but at times with an eagerness for the wonderful and sensational that carries the descriptions quite beyond the actualities of nature. We think nature's wonders wonderful enough when presented as they are without exaggeration from fiction.

11. *Paris Academy of Sciences.*—Professor Asaph Hall has been elected a corresponding member of the Astronomical Section of the Paris Academy, to fill the place made vacant by the death of M. Santini.

12. *British Association.*—The 49th meeting will commence at Sheffield on Wednesday, Aug. 20, 1879. The President elect is Professor G. J. Allman.

13. *American Association.*—The next meeting will be held at Saratoga, commencing on the last Wednesday in August. Professor G. F. Barker is President.

14. *A Memoir of Joseph Henry: a Sketch of his Scientific work;* by William B. Taylor. 140 pp. 8vo. Read before the Philosophical Society of Washington, Oct. 26, 1878.—An excellent memoir, admirable in its full, appreciative and learned discussion of the scientific labors and discoveries of Professor Henry.

15. *Observatory on Mount Etna.*—The plans of the Mount Etna Observatory, submitted to the Italian State Secretary for Public Buildings, have been sanctioned.

16. *Early Man in Britain and His Place in the Tertiary Period,* is the title of a new work by Professor Boyd Dawkins, soon to be published by Macmillan & Co.

OBITUARY.

Prof. Paolo Volpicelli, the eminent electrician of Rome, died on the 14th of April.

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[THIRD SERIES.]

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ART. XIII.—*Terminal Moraines of the North American Ice-Sheet;* by WARREN UPHAM.

MOST important additions to our knowledge of the glacial drift have been recently made by the Geological Surveys of Wisconsin* and New Jersey,† in discovering and tracing across these States distinct series of hills which appear to have been accumulated at the margin of the great ice-sheet, corresponding to the terminal moraines of alpine glaciers. The contour of these deposits is very irregular, consisting of ridges, mounds and hills, varying usually from 50 to 150 feet in height, scattered and joined to each other without order or in rudely parallel and interlocking ranges, which mainly trend in the same direction as the whole series; with many equally irregular enclosed depressions, which are bowl-shaped, trough-like, or crooked and branched, often containing ponds. The material is in some portions till, or a confused mixture of bowlders, gravel, sand and clay, entirely unstratified; elsewhere it has few or no bowlders, and consists of rounded gravel and sand worn and deposited in layers by currents of water. Different epochs in the glacial period are evidently marked by these series of hills, for that which crosses New Jersey bounds the area of striated ledges and till, which extend south to this line but not beyond it; while in Wisconsin these morainic hills are three or four hundred miles north from the extreme limit of the glacial drift. The former series is thus shown to have been accumulated when the ice-sheet had its greatest extent; but the latter belongs to a time when it halted and probably reädvanced, after a period of warmer climate had caused it to make a considerable retreat. In Ohio a belt of irregular drift-hills, which appears to be the second moraine, lies about seventy-five miles north from the boundary of glacial action, indicating a convergence of the two series toward the east.

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* Geology of Wisconsin, vol. ii, 1877, pp. 205–215 and 608–635.

† Annual Report of the State Geologist for the year 1877, pp. 9–22.

In the region traversed by the writer for the exploration of these hills, including Long Island, southern Rhode Island and Block Island, and southeastern Massachusetts, with the adjacent islands of Martha's Vineyard and Nantucket, both of these terminal moraines are finely developed, lying five to thirty miles apart. The New Jersey series, marking the farthest limit reached by the ice-sheet, continues across Staten Island to the Narrows, and thence extends in a prominent range through the middle of Long Island* and its southern branch to Montauk Point. A second series, probably contemporaneous with that of Wisconsin and Ohio, is found on the north side of this island, from Port Jefferson eastward to Orient Point, the extremity of its north branch, beyond which it forms Plum and Fisher's Islands, and enters the State of Rhode Island at its southwest corner. Thence it is well shown at a distance of one or two miles north from the shore nearly to Point Judith, where it apparently turns southward into the ocean. Twelve miles to the south the first range is again lifted into view in Block Island, a knot of very irregular drift-hills, which resemble those of Montauk.

The sea covers the next thirty miles in the line of continuation of these series of hills, beyond which both of them rise above its waves again, the northern forming the line of the Elizabeth Islands, and bending to the northeast and north on the peninsula of Cape Cod to near North Sandwich, where it turns at a right angle, and thence runs along the west-to-east portion of the Cape and extends into the ocean at its east shore. The southern moraine forms No Man's Land, the crest of Gay Head and prominent ranges of hills in the northwest part of Martha's Vineyard, extending northeast nearly to Vineyard Haven. Here this series apparently bends to the southeast, somewhat as the northern range turns at North Sandwich, but it is covered beneath plains or the sea for much of the way beyond this point. It appears unmistakably, however, on Chappaquiddick and Tuckernuck Islands, and in Saul's Hills and Sankaty Head on Nantucket.

The length of the southern moraine in its course from Sankaty Head to No Man's Land is fifty miles, and its whole extent as yet traced, to the west line of New Jersey, is about three hundred miles. That of the northern moraine from the east shore of Cape Cod to the west end of the Elizabeth Islands is sixty-seven miles, while its total length to Port Jefferson is about one hundred and eighty miles. The distance between these series at Martha's Vineyard and westward varies from five to fifteen miles, but increases eastward to thirty miles, where they disappear finally in the Atlantic.

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* This series of hills on Long Island was well described by Mather, in 1843, in the Geological Report of the First District of New York, p. 161. etc.

The Extreme Terminal Moraine.—This series of drift-hills in New Jersey begins at the Delaware River, a few miles above Easton, and extends fifteen miles east-northeast to Townsbury; then twenty miles east by Hackettstown to Dover; thence it turns to the south-southeast fifteen miles, by Morristown; and next to the south-southwest five miles to the east part of Plainfield; where, and for ten miles southeast to Perth Amboy, it forms the well-known range called Short Hills. The contour of this series of deposits is in quite irregular hillocks, with frequent enclosed hollows and ponds. Its material is stated to be coarse unstratified drift, or clay, sand, gravel, and bowlders of large and small size, mixed indiscriminately together. The profile of the country crossed by it rises from about 300 feet above sea at the west line of the State to a height of 900 feet at the mountain west of Townsbury, and to 1,200 feet on Schooley's Mountain, ten miles farther east; near Dover it has a height of 900 feet, from which it descends to sea-level at Perth Amboy.

The continuation of this moraine into Pennsylvania appears to extend southwestward, being represented by a similar series of drift-hills, lately traced by Professor Frederick Prime, Jr.,* in the Saucon valley, ten to twelve miles southwest from Easton. He also discovers at about the same distance north from Easton a second moraine, reaching some twelve miles from the Delaware River at Portland, west-southwest to Wind Gap in Kittatinny Mountain. The perpendicular distance between the latter series and the west end of that which crosses New Jersey is about eight miles.

Eastward the terminal moraine of New Jersey is distinctly continued across Staten Island, where its course is northeast twelve miles to Fort Tompkins, which is situated on its crest at the west side of the Narrows. On Long Island it forms the site of Fort Hamilton, and thence takes a quite direct east-northeast course for twenty-four miles to Roslyn; next it runs nearly due east about sixty miles to Canoe Place and the Shinnecock Hills; beyond which it bends northeast eight miles to near Sag Harbor; and thence continues, with some interruptions, in a course to the east and east-northeast twenty-five miles to Montauk Point. This moraine on Long Island constitutes a very conspicuous line of hills, bordered along most of its course by nearly level plains on both sides. So striking is its topographic effect that it long ago came to be commonly known as the "backbone of the island."

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* Proceedings of the American Philosophical Society, vol. xviii, p. 85.

This range is the southeast boundary of Brooklyn, Newtown, and part of Flushing; forms the heights of Greenwood Cemetery, Prospect Park, the Cemetery of the Evergreens, Ridgewood Reservoir, and Cypress Hill Cemetery; runs close north of Jamaica and Creedmoor; and holds Success or Lakeville Pond nearly at its top. Prospect Hill in Brooklyn is 194 feet; Ridgewood Reservoir, 170; Richmond Hill, 138; Success Pond, about 200; and the highest hills near this pond and to the north and east, about 250 feet above the sea. From the Narrows to Roslyn this series of irregularly undulating hills is shown by many excavations, as for cellars, streets and railroads, to be composed of till, or unstratified glacial drift, full of bowlders, most of which are rough and angular, while some have their sides planed and striated. This is the true terminal moraine of the ice-sheet.

To the east from Roslyn this accumulation of till is for the most part covered by terminal deposits of fluvial origin, which form a series of massive, irregularly grouped and connected hills and ridges of gravel and sand, distinctly stratified, often in oblique layers, and containing water-worn pebbles of all sizes up to a foot in diameter, but having few large bowlders or none. Harbor Hill, the highest point on Long Island, Jane's, Ruland's and Osborn's hills are of this modified drift; as also is nearly the entire range, both in its lower portions and at its highest summits, through a distance of more than seventy-five miles, extending from Roslyn to Napeague. Wheatly and Kirby hills are exceptions, being composed of till, while in a few other places, generally of small area, bowlders are found in abundance. The hills of Montauk, along the extreme ten miles of the island, are overspread and filled with bowlders, but are yet plainly stratified, as shown by cliffs along the shore. Heights of these hills are as follows:* Harbor Hill, half a mile east of Roslyn, 384 feet above sea; Wheatly Hill, three miles farther east, about 380; Spring Hill, two miles northeast, and Kirby Hill, three miles east from last, each about 350; Jane's Hill, the highest of the West Hills, 354; the Dix and Comac Hills, about 250; Pine Hill and Mt. Pleasant, west of Ronkonkoma Lake, about 200; the Bald and Selden Hills, 200 to 300; Ruland's, the highest of the Coram Hills, 340; Homan's Hill, north of Yaphank, about 250; Terry's Hill, south of Manorville, about 175; Rock and Canada Hills, about 200; Spring

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* For many of these and foregoing heights on Long Island, I am indebted to Mr. Elias Lewis, Jr., of Brooklyn, who presented a portion of them in this Journal, III, vol. xiii, p. 235.

Hill, about 250, and Osborn's or Bald Hill, 293, the last two being a few miles southwest from Riverhead; the East Hills, and the range onward to Canoe Place, 150 to 200 feet; Sugarloaf, the highest of the Shinnecock Hills, 140; the Pine Hills, 150 to 250, reaching their highest elevation three miles southwest from Sag Harbor; Stony Hill, a mile northeast from Amagansett, 161; Napeague Hill, the highest of the Nommonock Hills, at the west end of Montauk, 135; the Hither Wood Hills, two miles east from last, about 200; the Rocky Ridge, east of Fort Pond, culminating in Fort Hill, about 150; Signal Hill, highest point of the Shagwannock Hills, east of Great Pond, about 150; east of Oyster Pond, about 100; Montauk Point, about seventy.

Depressions of fifty to one hundred feet below the highest portions occur frequently in this line of terminal deposits. That passed through by the railroad a mile southwest from Syosset, is about 140 feet above sea, being of nearly the same height with the plains at the south and north. Lake Ronkonkoma, the largest body of fresh water on the island, lies exactly in the course of this series of hills. Its area is stated to be about 460 acres; its height, fifty-four feet above sea; and its extreme depth, eighty-three feet. The only stream that crosses the line of this moraine on Long Island is Connecticut River, which rises on its north side and flows southward at the west base of Homan's Hill, its valley being here about fifty feet above sea. A few miles farther east, between Yaphank and Manorville, the railroad crosses this line on continuous plains about seventy-five feet above sea; as also does the Sag Harbor branch a few miles southeast from Manorville. The isthmus of Canoe Place, which joins the south branch to the main island, is composed of gravel and sand, less than a quarter of a mile wide and rising only twenty feet above sea-level. The portion of this moraine which occupies the next three or four miles eastward is widely famous under the title of Shinnecock Hills. Though comparatively low, they have been more noticed than other portions of this range, because the traveler finds his road winding among their irregular hillocks, knolls, ridges and hollows. They are better seen, also, because not covered by woods, which clothe the higher hills of this series extending from them to the west and northeast. Their material, as of the series generally from Harbor Hill to Amagansett, is irregularly stratified gravel and sand, with occasional bowlders, which here vary in size up to a diameter of fifteen feet. The roads from South Hampton to North Sea, from Sag Harbor to East Hampton, and thence to the Springs, cross the morainic line at depressions which are occupied by nearly level plains about forty feet above sea. The longest interruption in this series of hills on Long Island is at the low tract of recent beach-sand and marsh called Napeague, four or five miles in length and nearly two in width; beyond which are the pastured uplands of Montauk, extending ten miles, with depressions to sea-level at Fort and Great Ponds.

The cliffs on the south shore of Montauk, twenty to one hundred feet high, are constantly undermined by the sea and present fine sections, composed of stratified gravel, sand and clay, the latter usually containing intermixed gravel, while in most portions of all these beds occasional and sometimes frequent bowlders, up to three or more rarely five to ten feet in diameter, are embedded. No unstratified deposits were found in an examination of these cliffs for nearly seven miles, from Fort Pond to the light-house. The contour of this peninsula is very irregular, with many small ponds and swamps. Its surface is everywhere strown with bowlders, often very abundantly, so that they nearly cover the ground. These, however, very rarely exceed ten feet in diameter, being of small size as compared with the enormous blocks which are found occasionally near the north side of the island.

These accumulations of drift, reaching in an essentially continuous series of hills nearly 200 miles, from Delaware River to Montauk Point, and lying as already stated at the southern limit of glacial action, seem to be terminal deposits dumped at the margin of the ice-sheet during its period of greatest extent. The striated summits of all the mountains of New England, New York and northern New Jersey, show that the glacial mantle was at least a mile thick at a distance of 200 miles north from its southern edge. Its formation from the annual excess of snow-fall left unmelted would lead us to suppose that it would have a nearly level surface; and its motion southward, caused by the pressure of its much greater thickness far at the north, shows that these plains sloped toward their boundary. The Antarctic continent and the interior of Greenland are now covered by similar fields of ice. That of Greenland rises steeply at its edge, but after a few miles changes to a gently inclined plateau, elevated above the highest peaks of the land on which it lies, and apparently of immeasurable extent. Dr. Hayes found the angle of ascent on this plain to decrease from six to two degrees in thirty miles, at which distance he reached an altitude of about 5,000 feet. It is evident that such an ice-sheet, in being pushed over hills and mountains, must gather detritus and bowlders from them to be carried forward in its mass, which would thus become more or less filled with the material of the drift at least to the height of the peaks and ridges which it crossed. Differences of direction and angles of descent in the slopes of the surface of ice above, due apparently to inequalities in the amount of snow-fall and of melting upon adjacent regions, were sufficient to make angles and lobes at the termination of the ice-sheet, and also doubtless caused downward and upward currents, by which much of the drift gathered while crossing a nearly level area, would be distributed throughout the lower part of the ice, probably to the height of several hundred feet. The beds of loose material which had been produced by long-continued decomposition of the ledges or accumulated by previous glacial action, together with the thick fluviatile deposits that probably occupied the valleys, were ploughed up by this ice-sheet and thoroughly kneaded with each other. Very large amounts of detritus were also added from erosion of the rock-surface. Fragments of all sizes and in great profusion were loosened and wrenched away, while the ledges were everywhere worn and striated by bowlders and pebbles, which were rolled and dragged along under the vast weight of ice, breaking up and grinding themselves and the underlying rock into gravel, sand, and even the finest clay.

The material which was thus gathered, mingled and swept along in and beneath the moving ice, upon reaching its termination was accumulated in heaps and ridges of unstratified drift, full of bowlders, and identical with the till which generally overspreads the ledges and underlies the modified drift of glaciated regions. The moraines of Long Island and southern New England show the same division in the character of these unstratified deposits that appears throughout the region to the north, where the lower till, which seems to be the ground-moraine of the ice-sheet, is very hard and compact, dark and frequently bluish in color, with clayey detritus and its pebbles and bowlders planed and striated; while the upper till, commonly from one to five feet thick, appears to be material which was held in the ice-mass and dropped upon the surface at its melting, being distinguished by its comparative looseness, its yellowish color caused by the exposure of its iron to oxidation, the predominance of gravel and sand instead of clay, and by the abundance and large size of its bowlders, which have seldom been worn or rounded except by the weather.

The massive hills of gravel and sand which form so prominent a part in this series of drift deposits heaped at the terminal front of the ice-sheet, appear to have been brought by glacial rivers. The melting of the ice at and near its terminal front exposed the detritus which it contained to the washing of many rills and small streams through every summer; but before the retreat of these ice-fields under a change of climate, their melting was extended over a very wide area. Their surface was then hollowed into basins of drainage and channeled by rivers, which became heavily freighted with the gravel, sand and clay that had been held in the ice. A large portion of this gravel and sand was laid down at the edge of the glacial sheet, where these rivers descended to the lower open area beyond; and when the ice behind them disappeared these deposits remained as hills, marking where the border of the ice-sheet was even more conspicuously than its unmodified terminal accumulations of till. The latter appear with scarcely any modified drift in this moraine from Fort Hamilton to Roslyn; but thence to Amagansett a remarkable contrast is presented, the moraine of till being nearly everywhere buried by that of fluvial gravel and sand. Bowlders in these stratified deposits appear to have been brought by ice-floes or small bergs, borne on the glacial floods. Their abundance on Montauk may indicate a slight advance of the glacial sheet during or after the deposition of the stratified beds, carrying forward a multitude of bowlders which remained on the surface of the ice because they could not be removed by its streams. At its final retreat these would be dropped, forming a deposit of upper till.

Previous to the deposition of the series of hills of modified drift which we have described, it appears that the ice-sheet reached five miles south of this line, though perhaps only for a short time. This is shown by Manetto and Pine Hills, which extend in massive north-to-south ridges from the West Hills by Melville to Farmingdale. They are composed of stratified gravel and sand with rare bowlders, and have a height which declines from 300 feet above sea at the north to 150 at the south. Three miles farther east, and separated from the foregoing by a plain about 100 feet above sea, are the Halfway Hollow Hills, of similar character and nearly equal height, extending some three miles south from the west part of the Comac Hills. Opposite to these, on the north side of the west-to-east moraine series, are two spurs of the Dix Hills, which reach three or four miles north from this series, being likewise composed of modified drift, and declining in height northward from 250 to about 200 feet above sea. All these appear to have been deposited like kames, in ice-walled river-channels formed upon the surface of the glacial sheet when it was rapidly melting. The southern ridges are thus of earlier date than the principal series of terminal deposits, while those on the north were probably formed immediately after this series during the retreat of the ice-margin.

The part of Long Island south of this terminal moraine consists of nearly level plains of fine gravel and sand, five to ten miles in width and extending a hundred miles in length. The height of their north portion at the foot of the hills varies from fifty to one hundred and fifty feet above the sea. Thence they slope gradually to sea-level at the south side of the island. Heights upon these plains, determined by railroad surveys, are as follows: Jamaica, 40 feet above sea; Mineola, 103; Hicksville, 142; Farmingdale, 63; Suffolk Station, 90; Medford, 82. A very interesting feature of these deposits has been pointed out by Mr. Elias Lewis, Jr.,* who finds frequent ancient water-courses, fifteen to twenty feet deep, crossing these plains from the hills to the bays of the south shore; most of which are now dry, except that springs appear in them one to three miles from the coast. They are quite straight, with few tributaries, their direction being generally a little west of south. Thirty of these "plain valleys," as they are locally called, occur between East New York and Riverhead, a distance of about sixty-five miles. In some cases they continue below our present sea-level and may be traced nearly across the enclosed bays to the beach-ridge which divides them from the open ocean; showing that when these valleys were formed the sea at this latitude did not reach so high upon the land as now. The cause of this depression of the ocean we may well understand, when we consider how large an amount of water was taken from it and stored up in accumulations of ice. A different effect of these ice-sheets in high latitudes was to draw the sea by gravitation away from the equator toward the poles, making it rise much higher than now in the St. Lawrence valley and in arctic regions. The plains south of the terminal moraine, and the water-courses crossing them, appear to have been formed by the same floods that deposited the hills of modified drift along the edge of the ice-sheet. Much of their finer gravel and sand was carried forward by the descending currents and spread in these gently-sloping plains, while the channels of drainage, extending to the sea-level of that time, seem to have been made by the same waters at their lower stages.

Underlying this modified drift of the plains, and sometimes rising nearly or quite to the surface, as at the clay-beds of Bethpage, are pre-glacial formations of gravel, sand and clay, containing Post-pliocene shells and lignite in numerous fragments or occasionally in thin layers. No bowlders occur upon these plains or are encountered in digging wells, which however often penetrate to the fossiliferous beds. Below the various deposits of the terminal moraine, and under the drift upon the north side of the island, are similar beds holding recent shells and lignite. The greatest elevation at which any of these fossils have been found is in a well near Manhassett, where they had a height about 150 feet above sea.

Gardiner's Island shows a fine exposure of these pre-glacial formations overlain by drift in sea-cliffs, thirty to fifty feet high, at its southeast shore. Here in a distance of a sixth of a mile the lower strata rise in two anticlinals, which dip at angles varying from 10° to 45°. They consist of dull-red, brown, dark and black clays, and brown, yellow and white sands. These arched strata are overlain conformably by yellow sand and fine gravel, which farther east are interstratified with layers of white and dark gray sand and dark clay. About 300 feet east from the northeast anticlinal, these later beds dip 5° to 10° eastward, and lie in the following ascending order, beginning at the upper edge of the beach: dark gray sand, nine feet, underlain a little to the west by a compact ferruginous layer one foot thick, which separates it from white sand; overlain by six feet of lighter colored sand, its upper portion filled with shells* for two or three rods, at a height which varies with the slope from 12 to 20 feet above sea; next, 10 feet of dark clay, which thins out at 100 feet to the west, but increases in thickness to the east; then, about 8 feet of coarse gravel, with angular pebbles to 1½ feet in size, becoming coarser 150 feet to the west, where it holds angular bowlders 4 feet in diameter, these covered by about 10 feet of sand; which also forms the top of this section, resting on the gravel to a thickness of about 8 feet. The coarse gravel and overlying sand appear to be glacial deposits, and these, frequently with numerous and large bowlders, form the surface of the island, rising in hills 125 feet high. The shell-bed belongs to a period immediately preceding the ice age, in which the sea here had about the same temperature as now. The variously colored anticlinal strata are older than this, but yield no fossils. They are probably of the same date with similar clays on the northeast side of the same island, on the south side of Montauk a mile west from the point, and at Bethpage; as also with the lower portion of the cliffs near Brown's Point.† Further exploration is needed to compare these with the lignitic beds of Block Island and the upturned Tertiary strata of Gay Head.

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* This Journal, III, vol. xiii, pp. 142–146 and 215.

North of the extreme terminal moraine on Long Island, another series of plains of gravel and sand, varying from one mile to five miles in width, and of similar height and southward slope with those on its opposite side, extends from Syosset forty-five miles eastward to Riverhead, and thence continues along the north branch of the island nearly thirty miles more to Orient Point. The description of these plains belongs with that of the second terminal moraine, which lies at their north side. The probable origin, relation and significance of the drift deposits in central and southern Long Island having been now pointed out, similar explanations will be found applicable to their continuation eastward and to the like series of deposits farther north, so that little more than a plain description of them will be required.

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* The fossils of this place were described by Mr. Sanderson Smith, in the Annals of the Lyceum of Natural History of New York, vol. viii, p. 149. See also this Journal, III, vol. x, p. 282. Twenty-five species are enumerated, all of which, excepting one or two of more northern range, are now found living in these waters.

† Figured by Mather in the Geological Report of the First District of New York, Plate iv.

Block Island, six miles long and three and a half miles wide in its south portion, presents the next segment of the extreme moraine, which appears with the characteristic features already described for Montauk, from which it is distant about fifteen miles to the northeast. The first account of this island, by Verrazzano in 1524, says truthfully that it is "full of hills." Approximate heights of some of these are as follows: Beacon Hill, the highest point on the island, 210 feet above sea; hill one-fourth mile south, 205; Pine Hill, one-third mile northwest, 150; Sandy Hill, near Grace's Point, 105; Cherry Tree Hill, 140; Pilot Hill, 185; base of the south light-house, 152; Bush Hill, the highest in the north part of the island, 140. These are irregularly grouped, with many hollows containing ponds and deposits of peat. Sands' Pond is about 125; and Fresh and Mitchell's Ponds, about 90 feet above sea. Great Salt Pond, which lies at sea-level, contains some 1,000 acres; the contour of its bottom is found by soundings to be very uneven, like that of the adjacent land, its greatest depth being 72 feet.

The south shore of this island is a continuous line of bluffs, 40 to 150 feet high, and four miles long. At their northeast end, half a mile from the light-house, the section is upper till, two feet; underlain by typical lower till, dark, compact and full of rock-fragments, twenty-five feet, reaching to the upper edge of the beach. At 200 to 400 feet southwest from this, the section is upper till, eight feet; underlain by dark clay, stratified, fifteen feet; and this by yellowish gravel and sand, forty feet, to the beach. About a quarter of a mile thence to the southwest, the order is about five feet of stratified sand and gravel at top, with numerous bowlders; dark clay, fifteen feet; yellow sand and coarse gravel with irony layers, twenty feet; typical lower till, unstratified, about forty-five feet, to the beach. At the light-house the cliffs are 150 feet high, and consist of dark clay, stratified, with enclosed layers of gravel and sand, the clay predominating and forming three-fourths of the whole. This entire bank is stratified, often very irregularly, dipping 10° to 30° in different directions. Gravelly layers, containing pebbles up to one foot in diameter, mostly angular, often occur in thick beds of this dark clay; and occasional bowlders, up to two or rarely five feet through, are embedded in all these deposits; as also westward where sand and gravel prevail, though the dark clay continues abundant. At one point only, about a quarter of a mile northeast from Black Rock, are red, white and yellowish clays exposed. The bank here is forty feet high, and consists mainly of the dark clay, dipping about 40° to the west, and having layers of gravel and of these brightly colored clays interstratified with it. These were probably derived from erosion of older beds, and there can be no doubt that this whole line of cliffs from the base to top was deposited at the epoch of greatest extent of the ice-sheet.

Clay Head, at the northeast shore of Block Island, also exposes a bed of typical lower till at its north end, where the section is six feet of coarse gravel at top; lower till, four feet; and stratified sand, five feet, to the beach. The highest portion of these cliffs at a half mile south rises about 100 feet, and consists of gravel, sand and dark clay, irregularly bedded and inclined often 5° to 15° in different directions, with pebbles up to one foot occurring at many places in the clayey strata. This part of Clay Head seems to be wholly of glacial origin; but earlier beds, among which are some of white clay, with red clay in small amount, form the base of the bank a third of a mile to the south.

Lignite is found abundantly for a quarter of a mile south from the breakwater in the lower part of the bank, twenty to thirty-five feet high, which forms the shore. It occurs, as at Gay Head and on Long Island, in fragments, which here vary from an inch to a foot in length, preserving the distinct grain of the wood and closely resembling charcoal; and also in layers, which are here from three inches to two feet thick, generally friable and earthy, and sometimes much like peat. These fragments and layers are found both in dark clay and in white sand; the same beds also enclose layers of gravel and thin seams of white and red clay. These beds are in some places folded and contorted, but mainly lie in anticlinals of gentle slope, capped by stratified gravel and sand with enclosed bowlders. The surface of this island is partly of the same modified drift and partly till, both plentifully strown with bowlders up to ten and rarely twenty feet or more in diameter.

[To be continued.]

Art. XIV.—*Microphotography with Tolles's $\frac{1}{75}$ inch Objective;* by Ephraim Cutter, M.D.

In his admirable report to the Surgeon General of the U. S. Army, on microphotography with sunlight in 1871, Surgeon J. J. Woodward expressed the hope that others would carry out the idea he had inaugurated for demonstrating original work. The writer fully appreciates and acknowledges the great aid-of his suggestions, and if I have ventured to modify his methods it has been from the force of circumstances and peculiar obstacles to be overcome.

I think that my modifications have made the way plainer and have removed obstructions which the gentleman in question did not have to contend with. I may here remark that I can see no reason for preferring microphotography to drawing exclusively, or *vice versa;* there is no antagonism, micrology needs both methods. The history of the attempt at microphotography with the $\frac{1}{75}$ is as follows: In 1867, Dr. James H. Salisbury of Cleveland, Ohio, had a work ready for the press on the causes and treatment of consumption based on 850 cases. In 1868 I became acquainted with it. Not to enter into details it is enough to say that a yeast in the blood is deemed to be the cause. It is found a year before organic disease. Dr. Salisbury killed 104 hogs by consumption artificially induced by yeast and verified it by autopsies in all the cases. From my own knowledge the treatment based on this principle is successful beyond anything I have known before. In privately making these things known I was met with the greatest incredulity as to the evidence which was mostly micrological. In order to sustain the position of my master I took Dr. Woodward's advice and resorted to microphotography. In my labors I was warmly and generously aided by Dr. G. B. Harriman, D.D.S., of Tremont Temple, and to this gentleman I give the full share of whatever credit may have been attained in photographing with Tolles's $\frac{1}{75}$ inch objective for the first time, not but that the morphology of consumptive blood could have been photographed with lower powers, but I desired to show those interested that in elucidating the views of one who in my opinion has come nearer to the real nature of tubercle than any one before him I had employed the best instruments of precision that modern art has produced.

Conditions that were to be met.—1. It was necessary that the patient, the sun and the apparatus with assistants, should all be together, because the blood must be withdrawn from the life stream and transferred to the sensitive plate in the shortest space of time. 2. The work must be done at different localities so as to have plenty of material to select from and to avoid disturbing elements. From these considerations it is easy to see that the Woodward plan of a dark chamber large enough to hold the operators and assistants could not be adopted, as it could not be carried about.

Figure 1, is a drawing of my best apparatus. Scale $1\frac{5}{16}$ inch to one foot; the base is a black walnut $1\frac{1}{4}$ inch thick board 55 by 11 inches; it is finished with the high polish of the piano maker's art so as to be insusceptible to warping from drying or wetting; running through the middle of it are two brass strips 1 inch wide, $\frac{1}{8}$ thick and $\frac{3}{8}$ inch apart. Beneath the contiguous edges is a deep furrow or groove $\frac{1}{2}$ inch deep and $\frac{11}{16}$ wide. This is not shown in the cut; its object is to have all the apparatus move in one definite median line. At one end is seen the sun mirror 10 by $8\frac{1}{2}$ inches, swung on two arms mounted on a swivel-jointed base; this allows of universal motion. Next is a standard mounted on a base that is attached to the brass groove by a "T" inverted below; the mirror has the same T, the standard rises 15 inches in two grooved posts connected at the top it is $8\frac{1}{4}$ inches wide; a set screw runs through one of the posts; in the groove a quinque-laminated veneer $6\frac{9}{16}$ inches square runs. In it is a hole 4 inches in diameter which admits a collar; in this collar slides an 18-inch Voigtlander photographic objective about 3 inches in diameter; this is adjusted by the set screw in the side of the standard; next on the board comes the Tolles, A microscope stand. The mirror is removed or turned out of the way, the stage is vertical, the $\frac{1}{75}$ inch objective is that on the stand; the eye-piece is removed and the open end of the microscope is pushed within the tube of the camera whose lenses have been removed also. The camera is set up on a box in order to get the requisite height to bring the axis on a line with that of the microscope. The camera moves on the box and the box moves on the base. The three are connected as follows: a groove $\frac{1}{4}$ inch wide and $\frac{1}{8}$ inch deep is cut in the base exactly in the median line and at right angles to the length. This is filled by a piece of ebony $\frac{1}{4}$ inch to $\frac{1}{2}$ inch thick and 4 or more inches long. A brass plate is let into the ebony so that when it is secured by screws it forms the bar of the inverted T before alluded to. When *in situ* this T slides under the base board brass strips. This arrangement is good but don't stand travel by railroad. The same arrangement connects the mirror to the base board.

By the side of the camera is a rod 26 by $\frac{3}{4}$ inches. Two screw eyes are let into the base board just at the ends of the rod. A screw runs through the eye into the right end of the

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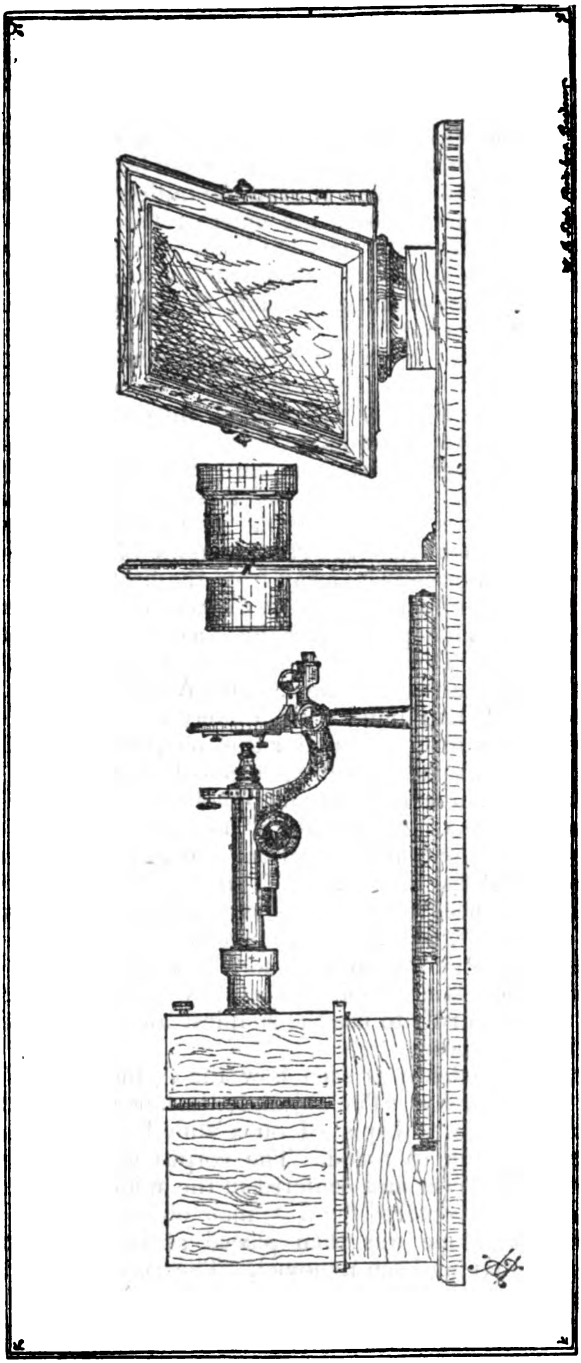

APPARATUS FOR MICROPHOTOGRAPHY.

rod, and another screw with a milled head goes through the other eye into other end of the rod. The rod is thus secured and rotates by turning the milled head; 17 inches of the rod are covered with sand set like sand paper; in the cut this is covered by a sleeve of enameled cloth as the sand is detached by contact. When used the sleeve is pushed back and a braid or tape is run over the rod and around the milled head of the fine adjustment. A pin secures the ends of the tape when the proper tension is made by drawing them over each other. The delicate focussing is made by the hand of the operator while the eyes are on the ground glass plate of the camera; the tape is not shown in the cut.

Remarks.—It will be noted that the peculiar features of this arrangement which differ from Col. Woodward's plain are, besides the portability; 1, The size of the condenser; 2, The absence of the ammonio-sulphate copper or alum cell.

1. This condenser probably is the largest ever employed in microphotography. The reason of this selection was simply to avoid heat. It is easy to see that if a two-inch condenser is regarded as sufficient that the same amount of light could be obtained with a three-inch, away from the heat focus and thus avoid the effect of focussing the sun's rays on the object and the objective. This practical point has been of great value and explains: 2, The absence of the contrivances to prevent the passage of destructive heat. Dr. Woodward has trouble with these cells, and judging from lately finding him engaged in making a new form of cell for this purpose, it would seem as if this cell was a disturbing element still, though in the hands of the father of modern microphotography.

We have taken a large number of negatives, some of which have received honorable mention abroad: see Journal de Micrographie, Paris, October, 1877, and have used no device to cut off heat; hence we feel justified in saving ourselves the trouble of a, to us, unnecessary appliance. In our opinion this cell has stood in the way of the more general adoption of the reproduction of microscopic objects by photography. We think it is a good rule to use the simplest and fewest things to accomplish a purpose.

For what precedes it is seen how the $\frac{1}{75}$ inch objective was used for photography. The object, for instance, enlarged white blood corpuscles, was displayed on a slide by the sudden drying of a thin film of blood. The corpuscles were found by means of a low power and centered in the middle of the field. Next they were centered by a $\frac{1}{50}$ inch objective, then by the $\frac{1}{75}$. The microscope was then placed as shown in the cut, the eye-piece having been removed. The axis of the condenser, microscope tube, camera and the center of the mirror were all ranged in one line. By means of the brass furrow in the base board the distances between them were changed without getting out of line. The sunlight, the chemicals, and all else had previously been found in working order by practical tests. Sunlight was thrown by the mirror through the condenser on the object which was placed just beyond the heat focus. We found that the brightest and clearest days, before 3 P. M., were the best. One observer, with his head and the camera covered with a black cloth, noted the projection of the image on the glass-ground plate. Another fingered the fine adjustment, or it was done by the focussing rod. When the image was satisfactory a card board cut off the light by interposition between the condenser and the object. The sensitized plate then replaced the glass plate and exposed, the regular exposure was made by lifting the card board and letting it fall in the course of half a second or more. The time varies and must be learned by trial. Usually it is shown by the action of the chemicals on the exposed sensitive film in the dark room. The processes afterward were those of the ordinary collodion process. It was necessary of course to look over the printing and instruct the printer how much exposure was needed.

In photographing yeast with the $\frac{1}{75}$ inch objective the object was wet and covered with a film of mica. The following facts may not be out of place. It was made by Robert B. Tolles, at Boston, and delivered July 1st, 1873. It was ordered by Dr. Harriman for the sake of working up his demonstration of the presence of nerve fiber in dentine. (American Journal Dental Science, May, 1870, Dental Cosmos, Jan., 1870.) Its angular aperture is 170 degrees; its actual opening on the face, $\frac{1}{64}$ inch. Cover adjustment moves about $\frac{1}{2}$ circle. Works wet or dry. Requires the aid of a powerful condenser. Usually it works best with a B eye-piece as a condenser under the stage, and with the thin edge of a common coal-oil flame shining "direct" into the condenser. It has to be used on a first class stand whose stage is absolutely at a right angle to the tube. With this direct light the field is clear, white and flat. The objective is very sensitive to jars and motions. This troubled us much. We have found in our experience that a cellar in a locality away from avenues of travel is the best place to work in. When an object is in focus with this objective a gentle grasp of the arm that connects the tube with the trunion joint (see cut) is sufficient to move the object out of focus.

The comparative excellence of this objective is not one for much discussion here; some have hastily said that it was of no value, not having used it, while others have looked at it with a sort of awe. In our opinion the question is not settled, though we think something toward it has been done. As far as our work has been concerned we know that we could not have attained our results with another objective like the $\frac{1}{18}$ for instance, with the ease and facility with which we did with the $\frac{1}{75}$. While we feel sure that the practical clinical results of corroborating our study of consumptive blood can be attained with objectives of $\frac{1}{8}$ inch power—and it would be sad if it were not so—at the same time we are sure that no wrong has been done to any one by pressing the $\frac{1}{75}$ into our service. Moreover, if by our simple arrangement we have been able to transfer images with the highest power objective ever thus used, those who possess the low powers ought to be encouraged to use microphotography with the sunlight without condensing, or with the ordinary mirror, or with the B eye-piece.

2.

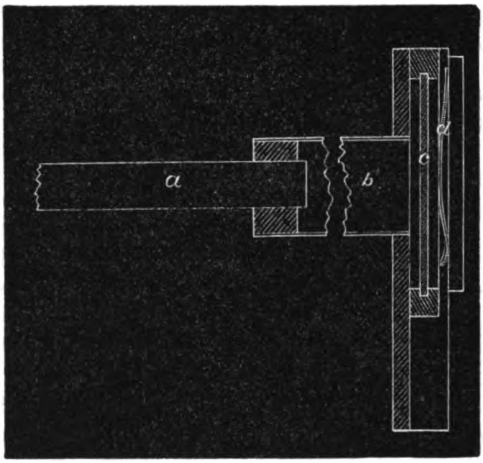

Figure 2 is a section of the writer's device for such work; it may be gotten up at a trifling expense. *a* is the tube of the microscope; *b* is a paper tube 30 by 2 inches. A nicely turned plug of wood adapts the microscope to the paper tube. To save space, the tube is broken off in the cut; a deal 8 by 12 by $\frac{3}{4}$ inches is seen in section, and fitted by a hole to the paper tube *b*. *c* is a section of the ground glass plate and holder, *d* is the clip to hold the plate holders. The artist has omitted the section of the lower cleat. This apparatus is adapted to a quarter plate and a two-inch photograph. An assistant should focus and adjust the light.

With these simple arrangements it would seem that the hope expressed at the outset of this article should begin to be realized.

Tremont Temple, Boston, April, 1879.

Postscript.—The first microphotograph of this objective may be found in the Yale College Library.

ART. XVI.—*Magnetic Strains in Iron;* by A. S. KIMBALL, Professor of Physics in the Worcester Free Institute of Industrial Science.

THE object of this paper is to describe certain experiments made by inducing a magnetic state in bars of soft iron subjected to varying degrees of mechanical stress. As the result, we always have changes either in the form or dimensions of the bar, similar to those produced by the mechanical stress previously applied, and therefore the term *magnetic strain* does not seem inappropriate. Some of the phenomena hereafter to be described have been observed by earlier investigators. These experiments have not been repeated with the expectation of detecting errors in their work, nor of attaining a higher degree of accuracy, but rather, to afford that valuable check which the reproduction of well settled phenomena, with a new disposition of apparatus, affords, both upon the accuracy of the instrument and the skill of the operator.

Effect of Magnetization upon the Tenacity of Iron.—The pieces of iron tested were pulled asunder by a Fairbanks testing machine of 53,000 pounds capacity. The machine consists: 1st, of a large platform scale; 2d, of a powerful screw-straining apparatus, driven by a belt from a shaft having eight changes of speed; the motive power is a Corliss engine which runs with great regularity; 3d, an automatic weighing attachment to the beam, by which it is kept constantly poised as the stress is applied to the test piece.

The delicacy of this adjustment was such, that when the testing proceeded at a suitable rate, the deflection of the beam from the zero point did not indicate a stress on the test piece differing more than two pounds from that shown by the position of the poise on the beam. The scale was "sensitive" to the addition of one ounce when the platform was loaded with 4,000 pounds; and on the removal of the small weight, the beam promptly returned to its normal position. The course of experiment was as follows: Several pieces of the same kind of iron, made as nearly as possible uniform in size, were broken in the machine. The alternate ones, in the order in which they were cut from the bar, were magnetized to saturation by a helix, through which a constant current was passing during the experiment. The heating effects of the helix were slight, and probably without influence. The tabulated results were then compared, and from them the following conclusion was reached: *A soft iron bar has its tenacity increased about nine-tenths of one per cent by magnetizing it to saturation.* The following table gives the results obtained by breaking a series of pieces of annealed iron wire, very uniformly drawn; approximate diameter, ·1623″. Length between the jaws of the machine, 5″. Time required to break the magnetized pieces, sensibly constant at five and one-quarter minutes; for the unmagnetized pieces slightly less.

TABLE I.

No.	Unmagnetized.	Magnetized.	Difference.
1	1201		9
2		1210	8
3	1202		11
4		1213	11
5	1202		14
6		1216	15
7	1201		9
8		1210	7
9	1203		9
10		1212	9
11	1203		
Mean,	1202	1212	
Minimum,	1201	1210	
Maximum,	1203	1216	
Difference between means,		10 lbs.	
Maximum difference between magnetized pieces,			6 lbs.
“ “ “ unmagnetized “			2 “

Another series of experiments upon telegraph wire gave 8·9 lbs. difference between the means. Seventeen pieces of wire were broken. A series of ten wires, one-quarter inch in diameter, gave an average of unmagnetized pieces, 4532 lbs., of magnetized specimens, 4572 lbs. Difference, 40 lbs.

Some hundreds of pieces were broken with the same results. A magnetized piece always proving stronger than the unmagnetized pieces taken from the coil or bar on either side of it. A few apparent exceptions to this rule showed flaws in the tested pieces on close examination. The average increase of strength in these experiments is very near nine-tenths of one per cent. In every case the strength of the unmagnetized pieces was much more uniform than that of the magnetized. In the Philosophical Transactions of the Royal Society, 1874, p. 571, Sir William Thomson predicts this result as a deduction from Mr. Gore's experiments on Electro Torsion.

Effect of Magnetization upon the Flexure of a soft iron Bar.—Joule's experiments upon the changes in dimensions of an iron bar when magnetized, formed the starting point for this part of the experimental examination in question. He has shown,* 1st. That if an iron rod be compressed longitudinally, it will be slightly elongated upon being made a magnet by a surrounding helix. 2d. That the amount of compression does not affect the magnetic extension so long as the magnetizing force remains the same. 3d. That the same phenomena, in kind and amount, occur in a bar which is neither compressed nor stretched. 4th. If the bar be subjected to tension, the elongation, on making it a temporary magnet, is diminished, and as the tensile stress increases the magnetic elongation diminishes through zero and becomes a shortening. 5th. Professor Mayer has shown[*] that, in the case of an unstrained bar, the first passage of the current elongates the bar more than any subsequent passage of the same current, and that the second, third and all subsequent elongations of the bar by a constant magnetizing force, are equal to each other; also that the shortening of the bar upon breaking the current is constant and equal to the second elongation. These facts, taken in connection with the common theory of flexure, fairly indicate one or two phenomena which will be found to attend the induction of a temporary magnetic state in a bar strained transversely. We see, from what has been said, that the neutral axis, and all the fibers on the concave side of the bar which have been shortened by compression, will be elongated by the action of the magnetizing force, while the fibers of the bar on the convex side, which have been subjected to tensional strain, will either be elongated by a less amount or will be shortened. As the result of this action we may be tolerably sure that the bar will be straightened. It is much safer, however, in this case, to proceed with our investigation experimentally, since neither the theory of magnetic action in iron, nor that of transverse elasticity, can be said to have been fully developed.

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* Philosophical Magazine, 1847.

The apparatus used in this part of the investigation was simple. A very rigid iron casting, with supports for a micrometer screw, and the ends of the iron rod to be examined upon its upper side, was placed upon the platform of a Fairbanks scale. The iron rod, carefully freed from magnetism and enclosed in its helix, was adjusted upon its supports so that the point of the micrometer screw was just below its middle. The helix was made in two parts for convenience in loading the bar. The middle of the bar supported one corner of a triangular platform, whose sides were four, eight and nine feet. The other corners of this platform were supported upon points. This disposition of apparatus proved very satisfactory. The load upon the bar was easily and accurately determined by the scales, while the stability of the triangular platform permitted the addition or removal of weight without seriously disturbing the adjustment of the bar. The micrometer screw had sixty threads to the inch, and its head was graduated to three hundred parts. The unit of measurement is therefore $\frac{1}{18000}$ of an inch. At first, contacts of the screw with the bar was determined by an electric bell, but the probable error of setting the screw being greater than one division of the screw head, a more exact method was sought. The following device was finally hit upon, which gave results which may be trusted to one-half divisions. The iron bar, micrometer screw, and a telephone were put in the circuit of a very weak Leclanche cell. When the screw was turned up to *loose contact* with the bar, the familiar boiling sound of a too sensitive microphone was heard, which ceased the instant *firm contact* was made. The change from the loud boiling sound to silence was abrupt and sharply defined. In the writer's experience this is by far the most reliable method of determining the contact of a screw. In the following experiments, bars of iron ⅝″ square and 24″ long, between the supports, were used. The helix and battery were powerful enough to magnetize it to saturation. The following table gives the results obtained in one series. Complete transcripts of the laboratory notes are given. The deflection of the bar increases with the readings of the screw. Of those readings only the tens and unit figures are retained, as the others may be easily supplied.

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[*] This Journal, August, 1873.

Column A, in the table gives the number of the experiment; B, the weight on the bar; C, total deflection after the weight is put on; D, increase of weight; E, increase of deflection due to increase of weight; F, scale readings when the current is off; G, scale readings when the current is on; H, decrease in deflection with the first current after a change in load; I, decrease in deflection with the second, third, etc., currents after a change in load; J=I−H.

TABLE II.

A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
1	Unknown.	Unknown.	Unknown.	Unknown.	87	--	--	--	--	21	22	481	8	173½	72	--	--	--	--
2					--	83	4	--	-	22	"	"	"	"	--	59	--	13	--
3					86	..	--	--	--	23	"	"	"	"	72½	--	--	--	--
4					--	83	--	3	--	24	"	"	"	"	--	59	..	13½	4½
5					86	--	--	--	--	25	30¼	652	8¼	171	43½	--	--	--	--
6					--	83	--	3	1	26	"	"	"	"	--	28½	15	--	--
7	5¾	140	5¾	140	26	--	--	--	--	27	"	"	"	"	45	--	-	--	--
8	"	"	"	"	--	19	7	--	--	28	"	"	"	"	--	28½	--	16½	--
9	"	"	"	"	27	--	--	--	--	29	"	"	"	"	45	--	--	--	--
10	"	"	"	"	--	19½	--	7½	--	30	"	"	"	"	--	28½	--	16½	1½
11	"	"	"	"	27	--	--	--	--	31	38¼	820	8	168	13	--	--	--	--
12	"	"	"	"	--	19	--	8	½	32	"	"	"	"	--	97½	15½	--	--
13	14	307½	8¼	167	95½	--	--	--	--	33	"	"	"	"	15	-	--	--	--
14	"	"	"	"	--	86	9½	--	--	34	"	"	"	"	--	97½	--	17½	--
15	"	"	"	"	97½	..	--	--	--	35	"	"	"	"	14½	--	--	--	--
16	"	"	"	"	--	86	--	11½	--	36	"	"	"	"	--	97½	--	17	1½
17	"	"	"	"	97½	--	--	--	--	37	46½	991	8¼	171	85½	--	--	--	--
18	"	"	"	"	--	86	--	11½	2	38	"	"	"	"	--	66	19½	--	--
19	22	481	8	173½	71	--	--	--	--	39	"	"	"	"	87	--	--	--	--
20	"	"	"	"	--	59	12	--	--	40	"	"	"	"	--	66	--	21	1½

A.	B.	C	D.	E.	F.	G.	H.	I.	J.	A.	B.	C.	D.	E.	F.	G.	H.	I.	J.
41	55	1160	8½	169	56	--	--	--	--	86	110¼	2346	7¼	165½	--	13	--	26½	--
42	"	"	"	"	--	37	19	--	--	87	"	"	"	"	39½	--	--	--	--
43	"	"	"	"	58	--	--	--	--	88	"	"	"	"	--	13	--	26½	1
44	"	"	"	"	--	37	--	21	--	89	119	2524½	8¾	178½	18	--	--	--	--
45	"	"	"	"	58½	--	--	--	--	90	"	"	"	"	--	92	26	--	--
46	"	"	"	"	--	37	--	21½	2¼	91	"	"	"	"	20	--	--	--	--
47	62¾	1325½	7¾	165½	24	--	--	--	--	92	"	"	"	"	--	92½	--	27½	--
48	"	"	"	"	--	4½	19½	--	--	93	"	"	"	"	20	--	--	--	--
49	"	"	"	"	26	--	--	--	--	94	"	"	"	"	--	93½	--	26½	--
50	"	"	"	"	--	4½	--	21½	--	95	"	"	"	"	21	--	--	--	--
51	"	"	"	"	26	--	--	--	--	96	"	"	"	"	--	93½	--	27½	1½
52	"	"	"	"	--	4½	--	21½	2	97	126½	2688½	7½	164	85	--	--	--	--
53	70½	1499½	7¾	174	90	--	--	--	--	98	"	"	"	"	--	59½	25½	--	--
54	"	"	"	"	--	68	22	--	--	99	"	"	"	"	87	--	--	--	--
55	"	"	"	"	92½	--	--	--	--	100	"	"	"	"	--	60	--	27	--
56	"	"	"	"	--	68	--	24½	--	101	"	"	"	"	88	--	--	--	--
57	"	"	"	"	92½	--	--	--	--	102	"	"	"	"	--	61	--	27	1½
58	"	"	"	"	--	68	--	24½	2½	103	134½	2862	8	173½	61½	--	--	--	--
59	78¼	1664	7¾	164½	57	--	--	--	--	104	"	"	"	"	--	34½	27	--	--
60	"	"	"	"	--	33½	23½	--	--	105	"	"	"	"	64½	--	--	--	--
61	"	"	"	"	58½	--	--	--	--	106	"	"	"	"	--	36½	--	28	--
62	"	"	"	"	--	34	--	24½	--	107	"	"	"	"	65	--	--	--	--
63	"	"	"	"	58½	--	--	--	--	108	"	"	"	"	--	37	--	28	--
64	"	"	"	"	--	33½	--	25	1¼	109	"	"	"	"	65½	--	--	--	--
65	86½	1837	8¼	173	21½	--	--	--	--	110	"	"	"	"	--	37½	--	28	1
66	"	"	"	"	--	98	23½	--	--	111	142½	3045	8	183	48½	--	--	--	--
67	"	"	"	"	21½	--	--	--	--	112	"	"	"	"	--	22	26½	--	--
68	"	"	"	"	--	98	--	25½	--	113	"	"	"	"	51½	--	--	--	--
69	"	"	"	"	21½	--	--	--	--	114	"	"	"	"	--	23½	--	28	--
70	"	"	"	"	--	98	--	25½	2	115	"	"	"	"	53½	--	--	--	--
71	94¼	2005	7¾	168	91½	--	--	--	--	116	"	"	"	"	--	25	--	28½	--
72	"	"	"	"	--	68	23	--	--	117	"	"	"	"	54	--	--	--	--
73	"	"	"	"	--	--	--	--	--	118	"	"	"	"	--	26	--	28	1½
74	"	"	"	"	--	68	--	25½	--	119	150¼	3224	7¾	179	33	--	--	--	--
75	"	"	"	"	--	--	--	--	--	120	"	"	"	"	--	6	27	--	--
76	"	"	"	"	--	68	--	26	2¼	121	"	"	"	"	36	--	--	--	--
77	103	2180½	8¾	175½	69½	--	--	--	--	122	"	"	"	"	--	8	--	28	--
78	"	"	"	"	--	44½	25	--	--	123	"	"	"	"	37	--	--	--	--
79	"	"	"	"	72½	--	--	--	--	124	"	"	"	"	--	9	--	28	--
80	"	"	"	"	--	44½	--	28	--	125	"	"	"	"	38	--	--	--	--
81	"	"	"	"	72½	--	--	--	--	126	"	"	"	"	--	10	--	28	1
82	"	"	"	"	--	44½	--	28	3	127	158¼	3415	8	191	29	--	--	--	--
83	110¼	2346	7¼	165½	38	--	--	--	--	128	"	"	"	"	--	2½	26½	--	--
84	"	"	"	"	--	12½	25½	--	--	129	"	"	"	"	31	--	--	--	--
85	"	"	"	"	39½	--	--	--	--	130	"	"	"	"	--	3½	--	27½	1

During the experiments with 94 and 103 pounds, students were passing to their recitation rooms on the same floor with the apparatus, making it quite difficult to determine accurately the contact of the screw. It will be seen that the deflections of the bar shown in C are proportional to the loads, as far as 120 lbs. Above this load the deflections increase more rapidly. Apparent variations from this law may be ascribed to want of accuracy in weighing, as there may be an error of ½ lb. either way, which corresponds to 6 scale divisions. The experiments were designed to show changes produced by the passage of the current, and accuracy in weighing was not at first deemed essential. The experiments described, and many others of a similar nature, seem to establish the following conclusions. If a soft iron bar surrounded by a helix and loaded as above be subjected several times to the action of a constant magnetizing current: 1st. The first time the current is made, the deflection of the bar is diminished. 2d. When the current is broken, the weight produces a greater deflection in the bar than before the current was passed. 3d. The second and subsequent currents produce a greater diminution of deflection than the first. 4th. The deflection during the passage of the first and every succeeding current is always the same. The same is true of the deflection after each current, but the deflection previous to the passage of the first current lies between those just specified. 5th. Although the second and subsequent currents have no power for the production of additional permanent magnetic strain as long as the load remains constant, yet, if the load upon the bar be increased, the first current after such a change produces a less effect than those which follow. 6th. If a part of the load be removed from the bar, the first current produces a greater change in deflection than those which follow; in this case, the deflection of the bar is permanently diminished by the first current. This may be illustrated by an extract from a series of experiments made with a diminishing load upon the bar—8 lbs. have just been removed.

A.	F.	G.	H.	I.	A.	F.	G.	H.	I.
101	126½	....	....	....	104	....	105½	....	18
102	...	105½	21	....	105	123½	....	....	....
103	123½	....	....	....	106	....	105½	....	18

The changes in the load upon the bar, heretofore referred to, have been made while the current was broken. 7th. If the load be increased while the current is on, the deflections when the current is broken will be constant, and the deflections with the second and subsequent currents will be greater than those obtained by increasing the load. The changes in deflection the first time the current is broken will be greater than those which follow.

Illustration—8 lbs. have just been added to the load while the current was passing.

A.	F.	G	H.	I.	A.	F.	G.	H.	I.
63	36½	--	--	--	66	---	8½	--	28
64	---	7½	29	--	67	36½	--	--	--
65	36½	--	--	--	68	---	8½	--	28

8th. If the load be diminished while the current is on, the deflections when the current is broken will be constant and the deflections with the second and subsequent currents will be less than those obtained by decreasing the load. The changes in deflection the first time the current is broken will be less than those which follow.

Illustration—8 lbs. have just been removed while the current was passing.

A.	F.	G.	H.	I.	A.	F.	G.	H.	I.
26	38	---	---	---	29	--	26½	---	11½
27	--	27½	10½	---	30	38	---	---	---
28	38	---	---	---	31	--	26½	---	11½

9th. Changes in deflection produced both by the first and by subsequent currents increase with the load on the bar up to the elastic limit, when they tend to become constant. Below the elastic limit, the law may be approximately expressed by the following formula:

$$(\text{change})^2 = a\ (\text{load} + b).$$

In the series of experiments given in table II, $a=7{\cdot}2$ and $b=5$, for changes produced by the second currents. 10th. Column J. of the table seems to increase slowly up to the elastic limit, and after passing that point to decrease slowly.

These experiments have been repeated with several grades of iron, and similar results have been obtained in every case; and though many points of the examination have been left incomplete, the writer believes that the conclusions stated above will be found substantially correct.

One point of interest may be noted here. This method of experiment to a certain extent eliminates the effect of temperature changes in iron, since these affect upper and lower fibers of the bar alike, while the phenomena we have been studying are produced by a differential action. How important this is will be seen in a subsequent part of this paper. If we attempt to use the results obtained by Joule and Mayer in explanation of the phenomena exhibited by the transversely strained bar, we find, at the outset, that, though some of them are explained readily, others appear contradictory, and others still need additional data. A series of experiments was next undertaken upon the magnetic elongations of soft iron bars, differing from those of Joule, in using a constant magnetizing current, also in using larger bars and greater tensions;—and from those of Mayer, in using bars subjected to varying degrees of tensile and compressive stress. Many of the results obtained by those accurate experimenters have been reproduced, and others have been obtained, which it is believed are novel and which certainly are interesting. The description of the apparatus employed, and the results obtained, are reserved for another paper.

[Since making the experiments described in this paper, the writer has noticed a reference to an article by M. Guillemin, on

"The straightening of a wire under the influence of a current," Walker's Electric Magazine, 1846. The magazine in question has not been found in any of the libraries consulted; it is therefore a matter of uncertainty how far M. Guillemin has anticipated the results here given.]

ART. XVII.—*The Lœss of the Mississippi Valley, and the Æolian Hypothesis;* by E. W. HILGARD, University of California.

[**Read before the National Academy of Sciences, April 16, 1879.**]

IN a highly interesting paper read before this body a year ago, and published in the February number of this Journal, Prof. Pumpelly, speaking of the lœss formation, sums up his views on the subject of the origin of these peculiar deposits in the statement that, rejecting his own previously expressed explanation, he is led to "believe with Richthofen that the true lœss, *wherever it occurs*, is a subaërial deposit, formed in a dry central region, and that it owes its structure to the formative influence of a steppe vegetation."

It is not my intention, at this time, to discuss exhaustively the question of the origin of the lœss in general, but rather to formulate some of the more prominent objections lying against the application of the æolian hypothesis to some of the lœss regions with which a long study has made me familiar. The expression "true lœss" leaves some doubt as to how Pumpelly limits the meaning of the word; but assuming that (as seems logically necessary) he uses it in the lithological as well as in its systematic sense, I desire to call attention to some points in connection with the lœss of the Mississippi Valley, which seem to render the æolian hypothesis untenable so far as regards that, and similar deposits elsewhere, which are clearly related to the troughs of large river courses.

The latter fact scarcely needs more than a cursory reference, if only to the circumstance that western geologists have habitually brought the lœss under the general designation of "bluff formation." The lœss of the Rhine, and of the Danube, are familiar to us in the same connection. It can hardly be that Pumpelly is not willing to consider these prototypes as "true lœss."

Now, what are the points in which the typical lœss differs so far from other aqueous deposits, that in spite of this obvious correlation we hesitate to class it as such? Aside from Richthofen's objections based upon the hypsometrical relations of the Chinese deposit (concerning the cogency of which I am unable to judge, not having seen his original publication), there are two principal ones, viz:

1. Absence of stratification.
2. Absence of fossils of aqueous origin.

As to the absence of stratification, it is admitted on all hands that even the most typical lœss, everywhere, often shows "bedding planes;" which manifest themselves more or less by a tendency to terraces, or lines of more rapid erosion on the otherwise vertical walls. This occurs more rarely in the central regions of the lœss masses; but on the peripheric ones it is not only quite frequent, but amounts in some cases to the most unmistakable appearance of aqueous stratification. Such is the case in the lœss bluffs of the Ohio in Southern Indiana, where my attention was called to it by Dr. David Dale Owen. It occurs also, though not quite so strikingly defined, along the edge of the "American Bottom" in Illinois, opposite and above St. Louis. Generally speaking, indications of stratification in the lœss are more frequent as we advance from the axial and lower regions of a river valley toward the sides and heads.

In the Sixth Annual Report of the Geological Survey of Minnesota, Prof. N. H. Winchell pointedly refers to the obvious transition of the lœss deposits into those of the newer Glacial period. Similarly, as stated in my Mississippi report (pp. 195, 298) and in a memoir on the Geology of Lower Louisiana (Smithson. Contr., No. 248, pp. 4 and 5), the lœss of the Lower Mississippi passes laterally, and by imperceptible degrees, into a clayey loam undistinguishable, in its final landward form, from that which forms the general subsoil of the Southwestern States; and almost precisely the same change occurs to the southward, in Louisiana, the representative deposits appearing, in that case, quite distinctly stratified into beds of materials more or less differentiated from the typical lœss.

Now, if the lœss of the Mississippi trough is of aqueous origin at the heads, the sides, and the lower end of that trough, and is, moreover, covered, normally, by a deposit whose pebbles and sand streaks can leave no possible doubt of a general shallow submergence immediately following, and terminating, the lœss period; it is not easy to see how the central portion of the deposit can have been in a subaërial condition, as required by Richthofen's hypothesis.

Is, then, the deposit of the Mississippi trough not a "true lœss?"—I have compared it carefully, in every respect, with the descriptions given of the characteristics of the lœss elsewhere, geologically, palæontologically, structurally and chemically; and I despair of finding any material differences, or such as may not be found, as variations, in any lœss district. It is true that the drainage of the Mississippi "cane hills" has not, as a rule, cut cañons with vertical walls, but narrow V-shaped valleys between sharp-backed ridges.* But wherever vertical cuts have been made, they stand like stone walls, unaffected by the weather; and even the subterranean villages of the Chinese lœss had their counterpart at the siege of Vicksburg. Where the deposit abuts against the older formations, we have a great abundance of land snails, as well as pebbles derived from the older drift, which usually appear in "strings" sloping away from the land. The "lœss-puppets," too, are there, varying in size, as the results of a mechanical analysis show, from the tenth of a millimeter to that of lumps and spindle-shaped masses weighing as much as ten pounds. The intimate vertical tubular structure I have not had occasion to verify; but long tubular concretions, apparently the casts of rootlets, occur frequently, not only in the older portions, but as a modern formation around decaying rootlets; which cannot be otherwise, since all the streams of the region are depositing calcareous tufa.

But if it must be admitted that the lœss of the Lower Mississippi is a true, typical lœss, exhibiting all the lithological and structural characteristics by which that deposit is recognized elsewhere; and that hypsometrical and stratigraphical data compel us to assume that it has here been formed under water: then the mainstay of the æolian hypothesis falls at once, for what has happened here can have happened elsewhere. Nor should it be forgotten that, if the lœss does not exhibit the usual features by which we are accustomed to recognize aqueous deposition, it is, on the other hand, equally devoid of the evidences of wind-drift structure, which ought to be very obvious at least in the windward portion of the lœss regions. On the contrary, it seems that all observers testify to its dead uniformity over the entire areas; so that with the exception of such differences as would be expected to occur from the rolling down of debris, and the local action of streams, there is no constant mechanical or chemical difference between the windward and the leeward regions. At least no such differences are reported in the United States; nor are they mentioned in the *resumés* of Richthofen's views that have been published.

As to the absence of almost all but terrestrial fossils, save locally where the material generally is more clayey, I cannot help suspecting some connection between this fact and the solution and re-deposition of carbonate of lime, so constantly and rapidly going on in these deposits. The adherents of the æolian hypothesis find no difficulty in accounting for the absence of every vestige of the vegetation which they consider as a more or less essential agent of its formation. According to them, this vegetation has left no mark but the tubes originally coating the rootlets. Now it is not easy to see, how under such circumstances any shell consisting of calcic carbonate can remain undissolved. I here recall to mind my observations on the deposits of the later (Grand Gulf) Tertiary of the Southwestern States; where in a deposit evidently formed on the shores of the Gulf, consisting of fine-grained sandstones, claystones, and in some cases silts scarcely distinguishable from that of the lœss period, we have such an absolute dearth of fossils that my most elaborate search in hundreds of localities, over an area nearly a hundred miles in width by two hundred and fifty in length, covered with rocks admirably adapted to the preservation of fossils and of an aggregate thickness of about 150 feet, has nevertheless failed to give any more definite clue to its fauna and flora than a few unrecognizable leaves, and a barely identifiable fragment of a turtle shell. The latter, however, was found in a stratum of clay containing an abundance of calcic carbonate in the shape of veins and irregular concretions, which in one locality at least showed plainly the general outlines of molluscan shells. The same features are repeated in the overlying strata of the "Port Hudson Group," which immediately underlie the lœss and are intimately connected with it. Here also there is an inexplicable scarcity of fossils; but calcareous concretions prevail everywhere, and fortunately, in some of the more clayey portions the maceration has only partially destroyed the forms of the shells; so that after tracing a stratum filled with concretions for miles, one will occasionally see these nodules taking shape, and finally, for a few feet, exhibit a very copious fauna, which, farther on, is again represented only by calcareous concretions.*

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* **See Rep. on the Geology and Agriculture of Mississippi, 1860, pp. 194, 313, ff.**

Cases in point are, of course, far from rare, and have probably come under the observation of most geologists in the field; but I think they have too often remained without mention, in the usual eagerness to find and describe well-characterized fossils. In my view, the wonder in the case of the lœss is, not that there should be so few vestiges of animal and plant life, but rather that any such should have escaped disintegration, under the oxidizing and dissolving processes that have been going on so long in so porous a material.

But why the exceptions in favor of the terrestrial animals? It seems to me that their localities of occurrence give a possible clue to the distinction. The destructive processes are essentially dependent upon the presence and percolation of water; and this should be least in the marginal portion, where as a matter of fact most of the terrestrial fossils are found. Whether in addition, there is a difference as to destructibility of land- as compared with fresh-water shells, may be a question deserving investigation. That the phosphatic bones should not have dissolved as easily as the mere carbonate shells, is readily intelligible; and as regards their mode of occurrence, I remark that in the lœss of the Lower Mississippi they are always very much scattered, many bones belonging to the same individual being rarely found together, but seeming to have drifted widely apart. It is not easy to see how the cumbrous bones of the Mammoth could have been widely separated in a subaërial deposit.

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* See my Memoir on the Geology of Lower Louisiana, and the Rock-salt Deposit of Petite Anse; Smithson. Contr., No. 248, 1872.

But I think that apart from its geological and other relations, there is intrinsic evidence in the nature of the material, contradictory of its æolian origin. In a paper lately published, I have drawn attention to a general distinctive feature of fine detrital aqueous deposits, viz: the necessary state of "flocculation" in which they are deposited, so long as the water is not absolutely quiescent. Excepting only under conditions of such moisture as would preclude the possibility of conceiving the wind as an adequate cause, dust deposits cannot be in a flocculated condition, but in the very nature of the case must consist of single grains closely packed. It is true that this axiom does not seem to accord with our every-day experience; for the dust of our roads, as well as that which we take off our furniture once a week, lies very loosely and is evidently not of a "single-grain" structure. But the organic "fluff," and hygroscopic and glutinous impurities causing this looseness of texture, could form no important part of the material carried by the supposed secular wind-storms of the lœss era. Now as the lœss is naturally one of the most porous and pervious of deposits, so as hardly to require tillage; and since moreover, it is shown by mechanical analysis to consist largely of minute spheroidal concretions—in other words, of floccules permanently fixed by the calcareous incrustation, precisely as should be the case if it *were* an aqueous deposit; while if a wind-deposit we should expect it to be cemented bodily into a continuous, rock-like mass: I submit that this structural peculiarity renders the aqueous origin of the lœss extremely probable. It may be possible to corroborate this argument, however, by direct experiment, in cases where the formation of calcareous concretions has not so far fixed the floccules as to render the production of slaty cleavage by pressure impracticable; and on the other hand, I intend to ascertain by direct trial, in what manner the lœss material will be deposited by an artificial wind, after freeing it from the calcareous cement by digestion in weak acid; and also, what will be the effect of pressure upon the material so treated, in the tamped condition on the one hand, and in the flocculated on the other.

Again, I am unable to see how the æolian hypothesis can account for the chemical peculiarities of the lœss. It seems to me to be very far from having the composition of the average rock dust of the earth's surface; nor does it present the chemical condition in which we would expect to find such dust. What has become of the feldspars, or of their products of decomposition? Admit that their dust would, by this time, all have been kaolinized, how can an average of two and a half or three per cent of alumina, shown by analysis, account for it? The previous decomposition products of the rocks of the great Western Plateau, as shown us by the Tertiary deposits, tell a very different tale, in the large prevalence of clayey strata; and it is from these very strata, moreover, that the largest part of the lœss material must, in one way or another, have been derived. It is easy to understand that the clay could be carried to the Gulf in suspension in *water;* but where did it finally lodge on the æolian hypothesis? If it be objected that, as stated by Prof. Brewer, "some of the lœss material is so fine as to remain in suspension for a year," I reply that although it will not stay so for one minute where any considerable amount of lime or other neutral salt is present in solution; yet, should the water be alkaline, the clay will remain suspended indefinitely. As there is a superabundance of sources of carbonated alkalies in the region in question, no objection can be raised to the aqueous origin of the lœss, on the score of its containing too much lime to permit the clay to escape to seaward. But I do consider that large average percentage of calcic carbonate, which so uniformly characterizes the lœss everywhere, as another serious objection to its æolian origin; it being out of all proportion to the alumina, not only on the score of general averages, but also on that of the slow, and almost exclusively aqueous mode of disintegration of limestone proper. If on the other hand, the lime was chiefly carried in solution, and from this assimilated by testacea whose shells were afterwards mostly destroyed by maceration, its presence is readily accounted for.

I do not, of course, pretend that the considerations I have here presented should be accepted as conclusive against the æolian hypothesis. But it seems to me that the points mooted require a fuller consideration than they have heretofore, so far as I am aware, received at the hands of the advocates of that hypothesis; and that they suggest a line of investigation not adequately pursued as yet. We are not yet cognizant of the precise nature of the varying conditions under which thick aqueous deposits apparently devoid of stratification may be formed; as they are even in flowing water, and may be seen in the deposits of the Mississippi River after any great overflow; as also in the stratified drift of the Southern States, where the "flow and plunge" structure is the rule. If it can be said (as I do *not* think it can) that no deposits similar to the lœss are now in process of formation by lakes: neither have we at this time, any example of the accumulation of such deposits through the agency invoked by Richthofen, on any considerable scale; although the postulated conditions exist in not a few regions. All dunes and drifted desert sands show wind-drift structure, as a necessary consequence of the varying velocity of the wind; and it seems to me that even in the presence of the supposed steppe vegetation, a condition of things under which that structure should nowhere appear, or should have been destroyed afterwards, is much more difficult to imagine than that, under the anomalous conditions of the "Champlain" period of depression, such conditions of aqueous deposition as we now find only exceptionally, should have prevailed more generally and for a longer time; a time, however, immeasurably shorter than that to which we must stretch our imagination for the formation of a thousand feet of dust deposit, brought by a wind so uniform in its direction and velocity as to leave no trace of the proverbial variability of that agent. And when we find ourselves driven to the supposition that this extraordinary wind did, moreover, drop its uniformly fine dust into the trough of the Lower Mississippi, leaving all the adjoining upland without a vestige for hundreds of miles on either side: the sum-total of anomalous conditions required to sustain the æolian hypothesis partakes strongly of the marvellous.

ART. XVIII.—*On a method of swinging Pendulums for the determination of Gravity, proposed by M. Faye;* by C. S. PEIRCE.

[Read before the National Academy Academy of Sciences, April 17th, 1879, with authority of the Superintendent of the U. S. Coast and Geodetic Survey.]

AT the Stuttgart, 1878, meeting of the International Geodetic Association, M. Faye suggested a method of avoiding the flexure of a pendulum-support which promises important advantages. The proposal was that two similar pendulums should be oscillated on the same support with equal amplitudes and opposite phases. If the pendulums could be made precisely alike, the amplitudes precisely equal, and the phases precisely opposite, it is obvious that the support would be continually solicited by two equal and opposite forces and would undergo no horizontal flexure, except from the distortion of the parts between the two edges. But since none of these three elements can be made equal, it is necessary to inquire what would be the effect of such slight imperfections in their equalization as would have to be expected in practice.

I had the advantage many years ago of learning the main characteristics of the mutual influence of pendulums from Professor Benjamin Peirce. As my father's studies of the subject were never, I believe, written out, I am unable to say definitely what I derive from that source. But the truth is the little knowledge I have of mathematics was learned from him, and from him I got a clear idea of the nature of this particular problem; so that acknowledgments of detail, even if I were able to make them, would be quite inadequate.

In M. Faye's proposed experiment, four finite forces would be in operation, namely: the weights of the two pendulums, the elastic force tending to restore the two knife-edge supports to their position of equilibrium when they are both displaced together, and the elastic force tending to restore them when their relative positions are displaced. The system has, also, four degrees of freedom corresponding to motions against each of the four finite forces. Accordingly there will be four differential equations of motion. By neglecting the terms of the second order, these equations are made linear, and by the general theory of such equations, they indicate that each of the four motions of the system (viz., those of the pendulums and of the two knife-edges) is compounded of four simple harmonic motions. Two of these will have periods nearly equal to those of the pendulums; the other two will be mere tremors having periods nearly those of the natural elastic oscillations of the supports. These tremors will be so small that they may be neglected. In fact, if we simply suppose that the knife-edges are constantly in equilibrium under the various forces which solicit them (which is simply to neglect their living forces under their very small velocities) the tremors disappear, to the great simplification of the formulæ.

Putting, then, φ_1 and φ_2 for the momentary angles of displacement of the two pendulums, s_1 and s_2 for the momentary horizontal displacements of the two knife-edges, l_1 and l_2 for the lengths of the two equivalent simple pendulums (on an absolutely rigid support), g for the acceleration of gravity, and t for the time, we have

$$l_1\frac{d^2\varphi_1}{dt^2}+\frac{d^2s_1}{dt^2}=-g\varphi_1$$

$$l_2\frac{d^2\varphi_2}{dt^2}+\frac{d^2s_2}{dt^2}=-g\,\varphi_2.$$

These equations are exactly like what we have in the case of a single pendulum on a flexible support; and I have shown their correctness in my paper on that subject.

There would be no difficulty in making the two pendulums so nearly alike that they might be regarded as entirely so in their actions on the stand, the whole amount of which is small.

We may also consider the parts of the stand on which the two knives rest as equally elastic. We may therefore take $\frac{1}{2}(s_1+s\ )$ as proportional to $\frac{1}{2}(\varphi_1+\varphi_2)$, and $\frac{1}{2}(s_1-s_2)$ as proportional to $\frac{1}{2}(\varphi_1-\varphi_2)$. Denoting, then, by x and y two constants whose values will be easily determinable by experiments we have

$$\begin{aligned} s_1+s_2&=(x+y)\ (\varphi_1+\varphi_2) \\ s_1-s_2&=(x-y)\ (\varphi_1-\varphi_2)\ ; \\ \text{or}\qquad s_1&=x\varphi_1+y\varphi_2 \\ s_2&=x\varphi_2+y\varphi_1. \end{aligned}$$

Substituting these values of s_1 and s_2 in the differential equations, and also writing $l+\delta l$ for l_1 and $l-\delta l$ for l_2, they become

$$(l+x+\delta l)\frac{d^2\varphi_1}{dt^2}+y\frac{d^2\varphi_2}{dt^2}=-g\,\varphi_1$$

$$(l+x-\delta l)\frac{d^2\varphi_2}{dt^2}+y\frac{d^2\varphi_1}{dt^2}=-g\varphi_2.$$

The solution of these equations is (A, B, t_1, and t_2 being the arbitrary constants)

$$\phi_1=\mathrm{A}\cos\left\{\sqrt{\frac{g}{l+x-\sqrt{(\delta l)^2+y^2}}}\cdot(t-t_1)\right\}+\mathrm{B}\cos\left\{\sqrt{\frac{g}{l+x+\sqrt{(\delta l)^2+y^2}}}\cdot(t-t_2)\right\}$$

$$\phi_2=-\mathrm{A}\left(\frac{\delta l}{y}+\sqrt{1+\left(\frac{\delta l}{y}\right)^2}\right)\cos\left\{\sqrt{\frac{g}{l+x-\sqrt{(\delta l)^2+y^2}}}\cdot(t-t_1)\right\}$$

$$-\mathrm{B}\left(\frac{\delta l}{y}-\sqrt{1+\left(\frac{\delta l}{y}\right)^2}\right)\cos\left\{\sqrt{\frac{g}{l+x+\sqrt{(\delta l)^2+y^2}}}\cdot(t-t_2)\right\}$$

The condition that the pendulums are started by drawing them away from their positions of equilibrium and then letting them escape nearly at the same instant makes t_1 and t_2 nearly equal. We may reckon the time from the mean instant of starting. Then at that instant we have very nearly

$$\varphi_1=\mathrm{A}+\mathrm{B}$$

$$\varphi_2=-\mathrm{A}\left(\frac{\delta l}{y}+\sqrt{1+\left(\frac{\delta l}{y}\right)^2}\right)-\mathrm{B}\left(\frac{\delta l}{y}-\sqrt{1+\left(\frac{\delta l}{y}\right)^2}\right);$$

or if we write z for $\frac{\delta l}{y}$,

$$\varphi_2=-\mathrm{A}\ (z+\sqrt{1+z^2})-\mathrm{B}\ (z-\sqrt{1+z^2}).$$

And since the amplitudes are nearly equal and the phases nearly opposite,

$$\varphi_1=-\varphi_2,$$

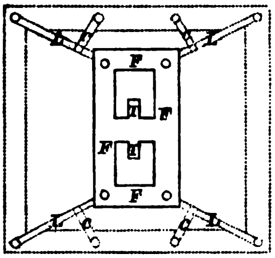
or $\mathrm{A}+\mathrm{B}=$(nearly) $\mathrm{A}\ (z+\sqrt{1+z^2})+\mathrm{B}\ (z-\sqrt{1+z^2})$

This gives

$$\frac{\mathrm{B}}{\mathrm{A}}=\text{(nearly)}\ \frac{\sqrt{1+z^2}-1+z}{\sqrt{1+z^2}+1-z}.$$

There would be no insuperable difficulty in making the pendulums so near alike that δl should be less than y, even if the latter quantity were smaller than it would be likely to be. But it will be seen presently that care must be taken in the construction not to make y too small. We shall have then $\delta l < y$ or $z < 1$; whence $B < A$. Thus the amplitudes of the first terms in the expressions for both φ_1 and φ_2 are greater than those of the second terms, while the period of the first terms is shorter than that of the second terms. From this it can be shown to follow that the whole oscillations of the two pendulums have the same period, which is that of the harmonic motions represented by the first terms of their values. Thus, in the figure, the abscissas representing the time, we have a wave of short period and large amplitude placed in comparison with a wave of long period and small amplitude.

1.



The phase of the short wave advances on the long one and goes over and over it. In each complete cycle of the curve representing the short wave, beginning and ending at $y=0$, it must cut the other curve twice unless the latter has mean time crossed the axis of abscissas once and not twice. When this happens there will be three intersections or only one, according to the direction of the crossing. Hence when the short curve has advanced over any even number of crossings by the long one of the axis of abscissas, the mean number of intersections per cycle of the short curve will be exactly two. Now let the short curve represent the first term in the expressions for φ_1 or φ_2 and let the long curve represent the second term *with its sign changed;* then, the intersections will represent passages of the pendulum over the vertical, and it will be seen that there are two for each complete period of the quicker harmonic component of the motion.

The mean period, then, of the oscillation of either pendulum will be

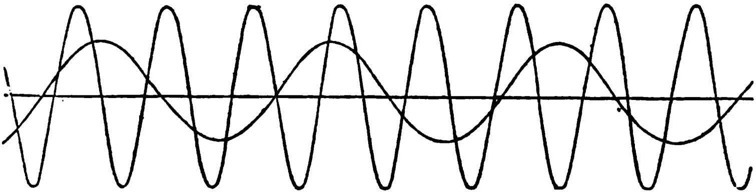
$$T = \pi \sqrt{\frac{l + x - \sqrt{(\delta l)^2 + y^2}}{g}}.$$

Now let us suppose that δl is so small that $\frac{1}{2}\frac{(\delta l)^2}{ly}$ may be neglected, being less than one millionth. This would happen, for instance, if l were one meter, y a half a millimeter (so that the stand would be somewhat less stiff than the Repsold tripod), and δl were one twenty-fifth of a millimeter, so that the difference between the natural times of oscillation of the two pendulums was not over four seconds a day, a perfectly attainable adjustment. Then the period would reduce to

$$T = \pi \sqrt{\frac{l+x-y}{g}}.$$

The terms $x-y$ here indicate that the apparatus would still be subject to a correction for flexure: but it would be only for the relative flexure due to the distortion of the support between the two knife-edges. This could of course be made very small. It would still have to be measured: but it would be measured once for all, since it would be the same at all stations. At present, the measurement of the flexure at each station, involving as it does the erection of a separate pier, threatens to be one of the most troublesome and expensive parts of the whole work of determining gravity. This would be entirely obviated by M. Faye's plan, except that the small differential flexibility would have to be determined once for all. The proper way to make the stand so as to bind the two knives to their relative position as firmly as possible while allowing a moderately large flexibility to the whole stand, so that the two pendulums could freely influence one another, would easily be found out.

2.



The accompanying figure, for instance, represents one such arrangement as viewed from above. T, T, are tongues upon which the pendulums would rest. These would be cast in one piece with the heavy frame F, F, F, F. This frame would rest on four legs L, L, L, L, which would spread at the bottom in the direction of the motion of the pendulum. At the bottom they would be bolted into another heavy frame. The cross braces C, C, C, C, would prevent twisting.

The average period of oscillation of either pendulum, after correction for flexure, would be that belonging to a simple pendulum having the length l, the mean of the lengths of the two simple pendulums whose natural periods of oscillation would be the same as those of the given pendulums. But although this would be the average time of oscillation of either pendulum, yet neither pendulum would have all its oscillations of the same duration. It is, therefore, necessary to inquire what error might arise owing to the observations not extending over any exact number of cycles of motion, so that the mean of the observed periods would not be the same as the mean of the periods of a cycle.

The quickest oscillation of either pendulum would occur when the phases of the component harmonic motions were coincident, the slowest when these phases were opposed. The period of the slow harmonic component motion would be

$$\pi\sqrt{\frac{l+x+y}{g}}$$

or the mean of the periods of the two given pendulums oscillating on the given stand with coincident phases, so as to be affected by the flexibility of the whole stand but not by its liability to distortion. Suppose, then, that in the course of the experiment an instant comes at which the pendulums are vertical at once. Let us reckon the time from this instant, and put

$$\mathrm{I}=\frac{\mathrm{A}}{\mathrm{B}}\cdot\frac{\sqrt{1+z^2}-1+z}{\sqrt{1+z^2}-1-z},$$

so that I is nearly unity. Then using the abbreviations

$$\sin_1=\sin\left\{\sqrt{\frac{g}{l+x-\sqrt{(\delta l)^2+y^2}}}\cdot t\right\}$$

$$\sin_2=\sin\left\{\sqrt{\frac{g}{l+x+\sqrt{(\delta l)^2+y^2}}}\cdot t\right\}$$

we have

$$\mathrm{C}\,\varphi_1=(\sqrt{1+z^2}+1-z)\sin_1\pm\mathrm{I}\,(\sqrt{1+z^2}-1+z)\sin_2$$

$$\mathrm{C}\,\varphi_2=(-\sqrt{1+z^2}-1-z)\sin_1\pm\mathrm{I}\,(-\sqrt{1+z^2}+1+z)\sin_2,$$

where the double sign distinguishes between coincidence and opposition of the phases of the harmonic constituents at the zero of t.

Then since the value of z is between 0 and unity, the values of these four coefficients lie

$\sqrt{1+z^2}+1-z$ between	2 and	1·414
$\sqrt{1+z^2}-1+z$	0	1·414
$-\sqrt{1+z^2}-1-z$	-2	$-3·414$
$-\sqrt{1+z^2}+1+z$	0	0·586

It follows that for one pendulum the phases of the harmonic constituents are coincident at the moment when they are for the other in exact opposition. Hence, one pendulum is making its slowest oscillation at the moment when the other is making its quickest, and *vice versa*. Then from the symmetrical character of harmonic motion it follows that if observations were taken of both pendulums during any interval of time, then the mean of the average periods of the two during that interval, would give the mean period of either through a complete cycle of motion. A better method of observing, however, would be to set up a lens between the two pendulums, so as to bring the plane of oscillation of the one into focus on the plane of oscillation of the other. Then, by means of a reading telescope set up at a little distance, the oscillation at which both crossed on the vertical could be noted with some accuracy. It would then only be necessary to determine the mean period of oscillation of either from one such event to another. As the difference between the longest and shortest periods of oscillation would only amount to a few ten-thousandths of a second, it would not be necessary to be very exact in the time of beginning or ending the experiment. The number of oscillations between one coincidence at the vertical and another would afford a very accurate determination of y. For suppose n to be that number. Then

$$n\sqrt{\frac{l+x-y}{g}}=(n-1)\sqrt{\frac{l+x+y}{g}},$$

whence

$$l+x=\left(n-\frac{n-1}{2n-1}\right)y.$$

But as n is large (several thousand) we may take $\frac{n-1}{2n-1}=\frac{1}{2}$, and x as equal to y.

This gives $y=\frac{l}{n-\frac{3}{2}}$.

Then $x-y$ having been determined, we ascertain the value of x also.

The greatest departure of the oscillations of the two pendulums from complete opposition of phase would occur when the phases of the harmonic components differed by a quadrant. In this case, the pendulums would cross at an angle equal to CI$\frac{\delta l}{y}$ from the vertical. The difference in the time of their passage over the vertical could only amount to a minute fraction of a second.

If the pendulums should not be nearly enough adjusted to the same natural period, or if the stand should be too stiff, so that δl were greater than y, the slower harmonic component would have a greater amplitude than the quicker one. In this case, the pendulums would pass over all differences of phase, and whether the mean period of oscillation were that of the faster or of the slower component might depend upon the initial phases, or, if δl were still larger relatively to y it might be the same as if the pendulums were oscillating with coincident phases. Care would have to be taken to avoid such a state of things.

On the whole, it appears that the suggestion of M. Faye, though it was thrown out on the spur of the moment, and was not received with very warm approval on every hand, is as sound as it is brilliant, and offers some peculiar advantages over the existing method of swinging pendulums.

Feb. 17, 1879.

ART. XIX.—*Geology of Virginia: Continuation of Section across the Appalachian Chain;* by J. L. CAMPBELL, Washington and Lee University.

IN the number of this Journal for July last, a general outline of the geology of the Great Valley of Virginia was given, and illustrated by a section embracing the several epochs represented in the valley proper, and in the two mountain ranges forming its boundaries on the southeast and northwest. That section may be regarded as a typical representation of the several varieties of rock that come to the surface for many miles on both sides of it.

In the present paper I propose to give what may be regarded, in part at least, as an extension of the same section—the results of observations made in the same general direction, but not exactly on the same line. Moving the line of section about eight miles toward the northeast of my former route, I shall fall back and begin again within the limits of the Great Valley; the reasons for which are, first, to renew the connection with the lower Silurian limestones, that will again make their appearance in an interesting anticlinal valley at the other end of the section; and secondly, that we may pass through or near a considerable number of points of no little interest, and easily accessible to the scientific traveler or the student of geology.

What is here presented is, in its main features, the result of a survey made several years ago, in conjunction with the Hon. Wm. H. Ruffner, LL.D., the present Superintendent of Public Instruction in Virginia, and who is a gentleman of no mean attainments in geological science. Some important details that are introduced, as well as some of the generalizations, are the fruits of subsequent observations made by myself in review of our original work. The main conclusions, however, stand as originally agreed upon.

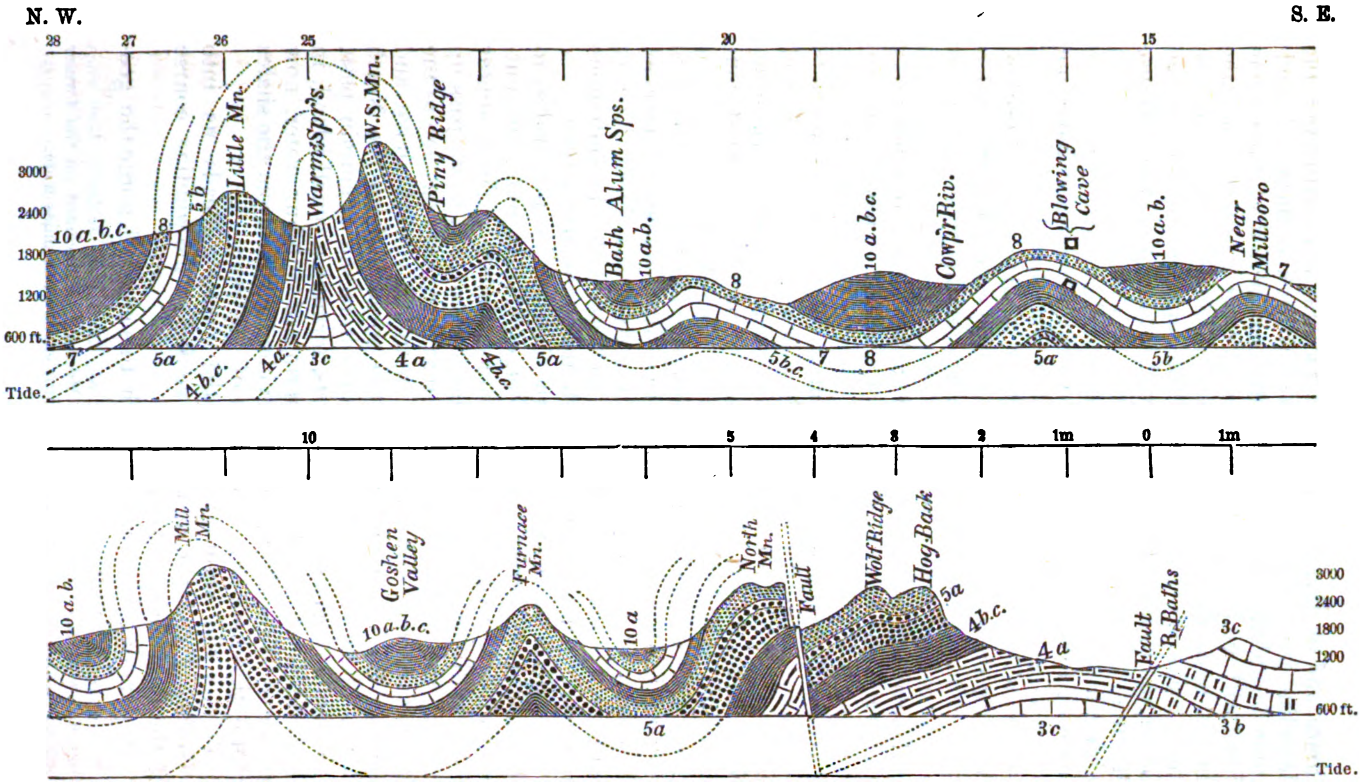
It would hardly be proper to call this an "ideal" section, since some of the most interesting portions of it represent *real* sections that nature has opened up to our view on a grand scale—where the geologist may revel, or the student of science find interesting and profitable employment for many days together. It passes through or near several mountain gorges of considerable depth and extent, as well as many points of minor interest, where mountain streams have cut their channels through the lower hills and thus exposed the various formations along its lines.

On my former section the series of Professor Rogers was given with sub-divisions; and a table appended to present a comparison of these with the corresponding periods and epochs given in Professor Dana's Manual, so far as the equivalents have been definitely determined in this part of the Appalachian chain. On the section accompanying the present paper, the numbers and letters refer to Professor Dana's system.

Beginning, then, with the southeastern extremity, near the Rockbridge Baths, we find a natural section cut by the North River through a part of 3 *a* and the whole of 3 *b* and *c*, etc. (Calciferous, Quebec and Chazy=No. II Rogers). In the immediate vicinity of the Baths these formations are very much obscured by the Quaternary deposits of drift from the mountains above, but they may be studied conveniently at points a mile lower down on the river cliffs, or on the neighboring hills a little remote from the river, on the southwest side, where the section passes. For a description of the rocks of this period, the reader is referred to the number for July.

The line of fault presented on the former section continues, with a single interruption, some distance beyond the present section, crossing the river a short distance above the Baths (N.W.)—the older (3) being still thrust upward over the edge of the newer (4 *a*.) This junction of the displaced strata can be seen indistinctly along the river banks at low water, but may be more distinctly traced in the hills southwest of the river, and on Hays' creek northeastward.

This fault has doubtless much to do with determining the temperature of these thermal Baths, the waters of which have a temperature of 72° F., and are kept in gentle but constant agitation by escaping bubbles of gas, consisting largely of nitrogen and carbonic acid. The remedial virtues of the Baths have been long recognized. As we pass up the river in a northwesterly direction we soon find the Trenton limestones forming the bottom of the river-bed where the strike of the strata can be distinctly seen crossing the stream nearly at right angles. The same rocks also crop out on the neighboring hills, which generally have a rounded shape and are strewed with quantities of local drift from the adjacent mountain gorges. There are no cliffs here; for these argillaceous lime-



Section of Silurian and Devonian Rocks—Rockbridge and Bath Cos., Virginia.

stones and overlying shales were too fragile to withstand the denuding force of the vast floods of water and masses of sandstone bowlders that have, at some past period of time, come down with violence from the neighboring mountains and the valleys beyond. Both the lithological and fossil characters of these rocks show that they are the same as those on which Lexington stands; but here, as well as along the base of House Mountain, they are softer, and not so extensively permeated with white veins, as they are around Lexington, where the crushing forces to which they have been subjected have not only tended to harden many of the beds, but have produced innumerable fissures that have been filled up by infiltration, and now present beautiful veins of calc spar. But the underlying coraline bed that forms the base of this epoch, and crops out so conspicuously near Lexington, is not brought to the surface at this point, yet is found at the distance of a few miles on both sides of our present line of section. I have, therefore, included it.

At the distance of two miles above the Baths, we come to the base of Hog-back Mountain,* at its northeast terminus, and about a mile northeast of where our section crosses. Here the North River cuts it off from what was once its northeast continuation, called Jump Mountain. The Medina sandstones (Rogers, No. IV) that crop out along the faces of the two ridges sink gradually as they approach the river—showing a marked depression at the point where the river has found its way through. Such, however, is not the case with the contiguous and nearly parallel ridge of North Mountain farther west.

The spurs of Hog-back and the face of the main ridge, to the height of several hundred feet, display an extensive outcrop of 4 *b*, *c* (Utica and Cincinnati shales.) These appear occasionally beneath the hard sandstones of 5 *a*, as we pass up through the wild, winding cañon that here gives passage to the waters that come down from the mountain valleys above, and meet at the upper entrance of the gorge to form the North River. Just where the river issues from the mountain pass, the stream separates into two parts, forming a small island, in the middle of which rises a spring of sulphur water, now known as Wilson's Spring. It evidently rises from the shales of 4 *b*, that here form the bottom of the river.

This is the point at which the turnpike leads us into "Goshen Pass," through which we follow the winding course of the river for several miles.

In pursuing his course through this crooked gorge the geological student will find a problem to solve of no little complexity, arising in part from the windings of the river, and in still greater part from the rupturing and faulting of the mountains themselves. After passing the ends of both Hog-back and Wolf ridges (see section) at the distance of about a mile and a half above Wilson's Spring, he will find the course of the river nearly coincident with the strike of the Medina sandstones that here dip so steeply on the N.W. face of Wolf Ridge as to pass the lower beds beneath the stream, while those higher up are cut through in the direction of their strike. Within view of this point, and on the opposite side of the river, a great downfall from the next ridge (N. Mt.) has occurred, around which the stream makes a loop of half-a-mile in extent; this slip, however, is quite limited; for above, and on the right and left of the fallen mass the Medina sandstones again crop out along the face of the North mountain ridges with a moderate northwesterly dip, displaying their full thickness of about 500 feet along the southeast face, and, with one slight undulation, and subsequently increased dip passing beneath the Little Goshen valley beyond.

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* This and Wolf Ridge, immediately in rear of it, have evidently been once connected with the two ridges of House Mountain, represented on the former section; though now separated by a beautiful valley three miles wide.

After careful and repeated examinations of this portion of the "Pass," Dr. Ruffner and myself agreed that the phenomena presented could be accounted for only upon the hypothesis of a *fault* running parallel with the axis of the mountain chain. Repeated observations since our original survey have tended to confirm the conclusions originally formed.

In following the course of the loop in the river, mentioned above, we travel a short distance with the strike of the rocks toward the southeast, then turn and cross the fault (filled up with the débris from the face of the broken mountain), and finally change our course to the northeast again following the line of strike in nearly an opposite direction, and passing beneath the outcropping sandstones that rise far above our heads. But we soon deviate from this course to one at right angles to the mountain, and by which we are conducted through another natural section of 5 *a*, *b* and *c*, and apparently pass out, right upon the beds of Devonian shales. At the base of the mountain, however, from the gap of which we have just issued, 7 and 8 are concealed from view, as evinced by the fact that they crop out at many points along the base of the mountain at some distance from the road on both right and left. In this Little Goshen valley there are indications of extensive beds of limonite ores, some of which were worked many years ago. They are found in both 5 *b*, *c*, and in 8.

This valley offers no special facilities for studying the Devonian shales, which are found much more fully and favorably exposed farther west, but along its western border for a distance of four or five miles from the turnpike, in a northeasterly direction, some interesting developments of 7 and 8 are found along the foot of what is here called Furnace (or Knob) Mountain, through a gorge of which the Big Calf-pasture, the chief fork of North River, comes down from the Great Goshen valley on the west. In this gap tolerably well-defined arches of 5 *a*, are displayed on the right as we pass up the river, while on the left (Bratton's Mountain) the same rocks are overlaid by a bed of 5 *b*. The arch on the right hand is the one represented on the section.

Between this and Mill Mountain lies Goshen Valley, a beautiful agricultural region, and one that presents some points of scientific interest that are readily reached by the student of geology. The section passes near the Cold Sulphur Springs about 1½ miles southwest of Goshen depot on the Chesapeake & Ohio railroad. The waters of these springs flow from exposed strata of 10*a*, dipping slightly toward the Mill Mountain on the northwest. In this valley, as well as throughout this whole region, the Salina Period (6) is but indistinctly represented, if at all, while the Corniferous Group (9*a*, *b*, *c*), appears to be entirely wanting. But the very fossiliferous limestones of the Helderberg (7), and of the sandstones of the Oriskany Period (8) are well exposed at Craigsville, nine miles northeast of Goshen on the railroad, where a beautiful encrinal marble is quarried from 7, and also at points nearer to Goshen. Just west of Panther Gap in Mill Mountain (through which both railroad and turnpike pass), at several points a short distance from the base of the mountain, good exposures may be found. The mountain itself, at this point, is cut by Mill Creek, and its Medina sandstone axis is exposed in the form of a closed anticline pushed over toward the northwest so as to give all the strata a southeasterly dip.

Before leaving Goshen Valley we must observe the fact that, about the depot and the Cold Sulphur, the upper member of 10 has been swept off, and in many places a large portion of the middle member (*b*) has also disappeared. There is a ridge however, beginning a mile or less north of the depot, on which all the members (10*a*, *b*, *c*) appear. I have not found what remains of this group to exceed 450 or 500 feet any where in this valley.

Resuming our line of section west of Panther Gap we find the thickness of 10*a*, *b*, *c* to have increased and the lithological characters to have undergone some modifications. Beds varying from siliceous slates to argillaceous sandstones are found cropping out, especially in *b*, as may be seen both on the railroad and the turnpike. Large quantities of these rocks have been brought from the tunnel near Millboro depot. Calcareous concretions of a disc-like form, full of veins of infiltrated carbonate of lime (*septaria*), increase in size and number; while thin beds of fossil limestone, especially in *a*, are occasionally exposed to view.

At Millboro depot a line of stages leaves the railroad for the Warm Springs, fifteen miles to the west. At the distance of two miles we reach the old Millboro Springs where we again find sulphur water rising from the Devonian strata (10). Another mile brings us to the famous "Blowing Cave," where it is well worth while for the explorer to allow himself at least one full day. He is now upon the banks of the Cow-pasture River, one of the upper forks of the James. Here the river cuts through a ridge (Cave Hill), exposing to view an arch of Helderberg limestone (7) into which a cavern of unknown depth extends from which a breeze of considerable force issues continually in warm weather. Above the limestones is a second arch of Oriskany sandstone (8), in which are numerous Spirifer shells well preserved. These two formations may be studied here with great convenience; and, if an additional exposure is desired, it may be found two miles farther toward the northeast, where Stuart's Creek exposes a similar arch in the same hill, and where fine specimens of Favosites are easily obtained.

Exposures of the members of 10 may be studied along the banks of the Cow-pasture both above and below the passage through Cave Hill. A short distance below, in what is called "Alum Bank," we found a thin bed of limestone remarkably full of fossil shells. At other points higher up and lower down the river similar exposures occur.

Near this place is one of the numerous so-called "Alum Springs"—the *Wallawhatoola*, an old Indian name. The waters here, as at the Rockbridge and the Bath Alum Springs, collect slowly from the crevices of the dark pyritous shales of No. 10. Springs of this class are very numerous among the Devonian shales in Virginia; and waters of similar character sometimes issue from shales of earlier and later dates. Their chief mineral constituents are sulphates of alumina, lime, magnesia, potassa, soda, iron (*ferrous* sulphate), with more or less *free* sulphuric acid. In the Wallawhatoola I found, with the spectroscope, a decided trace of lithia.

The shales of this region, and especially in this valley of the Cow-pasture River, present three tolerably well characterized beds; the equivalents, no doubt, of the three recognized epochs of the Hamilton Period*—Marcellus, Hamilton and Genesee. The lower member consists of dark—sometimes black, sometimes bluish-black—shales that split readily into thin layers, and even fine scales or slender columnar fragments. The middle member has a decidedly greenish tint—olive in many places, especially where it appears along the public roads, and in cuts on the railroads. The highest division is much variegated in color and texture; the beds of shale are yellow, brown and red, while considerable strata of sandstone of argillaceous character are found alternating with the shales.

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*This is No. VIII of Professor Rogers's series.

Among all these are found beds of very calcareous shales passing often into impure limestones that abound in Encrinites, Atrypas, Spirifers, etc. The upper member has generally more calcareous beds in it than either of the others. This whole region has been greatly denuded, but the sharply rounded, and often cone-like hills that are left standing, with deep ravines cut out between them, present a striking feature of the landscape, and, at the same time, afford the means of an approximate estimate of the thickness of the whole series of shales, which cannot be less than seven hundred feet.

Along the faces of many of the hills that have been recently denuded by floods in the river and its tributaries, the planes of stratification, and of slaty (metamorphic) cleavage, are both well displayed—the latter so distinct that an unpracticed eye might readily mistake them for the planes of original stratification.

About four miles west of the Blowing Cave the turnpike crosses a ridge called Mair's Mountain, capped by a low arch of Oriskany sandstone (8), beneath which are exposures of the Helderberg limestones (7) where a small stream has cut its way through the ridge. Beyond this ridge we find another synclinal trough filled with the shales of No. 10, out of which rise the waters of the Bath Alum. Near this watering place is a cave formed by the washing out of the softer bed of Medina, rocks so as to leave a regular arch which becomes narrower and lower toward the rear of the cavern, giving the whole cavity the shape of a semi-cone with the dividing plane for the floor. This is an object of interest to visitors. Its location is beneath the ridge, marked "Piny Ridge," on the section.

A mile beyond the Bath Alum, our line begins to ascend the lofty ridge of the Warm Springs Mountain. To the structural geologist this presents an object of the highest interest. As we follow the windings of the turnpike we find ourselves surrounded first by the débris of the Clinton sandstones and shales (6 and 7 are concealed), and as we approach the crest of Piny Ridges the Medina sandstones (5 *a*) make their appearance *in situ*. We are thence conducted by a spur across to the face of the main ridges, where the road is cut out of the sandstones, exposing their lithological and fossil features in a very interesting way. Ripple marks and casts of shells in the brown and purple sandstones, and fucoids in the shales, are of frequent occurrence.

On reaching the depression of the summit where the road crosses, we turn to the left and follow the crest of the ridge for half a mile toward the southwest to the top of what is known as "flag rock"—the highest outcrop of Medina sandstone on this mountain, having a steep southeasterly dip. From this point, 3340 feet above tide level, the mountain scenery on all sides is very grand. Along the base of this ridge, on the northwest side, lies the Warm Springs Valley—a narrow strip of the Lower Silurian limestones of the Great Valley again brought to the surface. On the opposite side of this narrow valley another ridge, Little Mountain, rises to a less elevation, but is composed of the same kind of rocks as the main mountain, but dipping toward the northwest.* The olive-colored sandstones, generally found at the base of the Medina group in this region, appear near the summit of both these opposing ridges, and are succeeded by the fragile sandstones and shales of the Cincinnati and Utica epochs that form the steep slopes of both mountains. These are succeeded by the Trenton (4 *a*) limestones that dip beneath them, but form more gradual slopes toward the middle of the valley, where the older Chazy (3 *c*) limestones make their appearance. The latter are not largely developed where the tepid waters of the Warm Springs rise, but widen out considerably toward the southwest. A short distance to the northeast of the springs we found Trenton fossils in abundance, like those we had found just below the entrance of Goshen Pass.

In this anticlinal valley the Lower Silurian rocks come to the surface for a distance of several miles on both sides of the section, the general range being parallel with the Appalachian chain.

The two ridges that here face each other were doubtless parts of a great open anticlinal fold that was formed, when, by powerful lateral pressure from a southeasterly direction, the strata were pushed up from their original horizontal bedding. But it is hardly probable, judging from the present condition of things, that they ever formed complete arches across the valley. It is certainly more reasonable to suppose that such masses of strata of varying hardness and strength, and with an aggregate thickness of more than two thousand (2000) feet, were so ruptured at the time of upheaval as to form a rugged gorge, extending for many miles along the crest of the fold, and that subsequent erosions and denudations by ice and water widened it out, and shaped it into the beautiful valley as we now find it. This is a valley of thermal waters; for, besides the Warm Springs, near which our section crosses, and the baths of which range in temperature from 95° to 98° F.; the Hot Springs, five miles to the southwest, with temperatures varying from 100° to 108° F., and the Healing Springs in the same neighborhood, with a temperature of 85°, rise in the same anticlinal fold.

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* Along some parts of this broken ridge the sandstones are vertical or even inverted.

About half a mile southwest of the Warm Springs the collected waters of this portion of the valley find their way out in a northwesterly direction through a deep ravine, in which are found exposures of all the formations from 4 to 8.

General remarks.—(1.) Throughout the whole region represented on the accompanying section, conformity of strata prevails, and so continues till we reach the Carboniferous in West Virginia. (2.) The Medina sandstones that are from 405 to 500 feet thick along the North Mountain thin out to about 350 on Warm Springs Mountain. Here, too, the structure is less conglomerate, and the marks of shore-line formation are less numerous and distinct than they are farther east. (3.) It may be well to mention some of the prominent points along the line of section convenient for observation. At the lower entrance of Goshen Pass, and in Warm Springs valley, exposures of 4 may be readily found. No. 5 (Medina) may be successfully studied in Goshen Pass and on Warm Springs Valley; while the region around Millboro Springs affords to the explorer some of the finest exposures of 7, 8 and 10. But the accompanying section may serve as a key to a wider range of observation. Perhaps the best point of departure would be Goshen, on the C. & O. Railroad. If he wishes to extend the section farther toward the northwest, the turnpike from Warm Springs to Huntersville, in West Virginia, affords a favorable route for horse-back explorations.

Washington and Lee University, Va., April, 1879.

ART. XX.—*On the Discovery of a supposed new Planetoid;* by Prof. C. H. F. PETERS. From a letter to the Editors dated Litchfield Observatory of Hamilton College, Clinton, N. Y., July 13, 1879.

THE following are the results of two observations on a planetoid found here on the 9th inst., which seems to be new.

1879.	Mean time.	α (198).	δ (198).	No. of comp.
July 9.	$11^h\ 36^m\ 48^s$	$17^h\ 22^m\ 11^s{\cdot}16$	$-23°\ 22'\ 7''{\cdot}2$	4
July 10.	12 32 24	17 21 21·15	−23 27 29·5	8

Comparison star for both evenings was θ Arg. 16826. Last night I succeeded again in getting a good set of observations, which, however, are not yet reduced. The planet is rather of the fainter class of the 11th magnitude, and on account of its southern position a difficult object, if the sky is not quite serene.

Should the planet of Mr. Palisa of May, after the final discussion of the observations, turn out to be a new one and not identical with *Adeona*, the present one will be number 199.

Art. XXI.—*Notes on the Laramie Group of Southern Colorado and Northern New Mexico, East from the Spanish Ranges*; by John J. Stevenson, Professor of Geology in the University of the City of New York.

The most southern of the Laramie coal fields along the eastern base of the Rocky Mountains lies partly in Colorado, and partly in New Mexico. It is rudely lozenge-shaped and has its greatest breadth near the southern boundary of Colorado, whence it tapers in each direction, pointing out at the north near Cucharas Creek, forty miles from the state line, and terminating at the south immediately beyond Cimarron Creek, thirty-six miles south from the Colorado line. Its area is not far from 2200 square miles, and the whole of it, save perhaps 150 square miles, is included in the district examined by me during the season of 1878. With consent of the Chief Engineer, U. S. A., a brief synopsis of results is offered here in advance of the report to be presented to Lieutenant Wheeler.

This field is separated from the Spanish Ranges by a meridional valley, from one-fourth of a mile to nearly two miles wide. Its eastern border is well-marked by a line of high bluffs, facing the plains and showing the lower rocks of the Laramie resting on the higher shales of the Colorado group. The extreme breadth along the state line is due to the presence of a basalt plate covering the Raton* Plateau, whereby the rocks have been protected from erosion, so that the lower members of the group reach to, say, twenty-three miles south of east from Trinidad, Colorado. No part of the Laramie group exists on the Purgatory or the Canadian Plains north or south from the plateau, west from longitude 104° 7′, or south from north latitude 37° 20′; but the Middle Cretaceous rocks, those at the base of Cretaceous No. 4, immediately underlie the Quaternary deposits on those plains and extend for several miles up all of the cañons on the eastern side of the coal-field.

Three petty anticlinals were traced out as affecting the Laramie beds. They are important, economically, as they keep the coals within reach.

The Laramie group is represented here by sandstones, shales and coal beds. The sandstones, with few exceptions, are yellowish-gray, and each is an almost exact copy of every other, the only material variations being in thickness. Persistent limestone beds, with marked characteristics, are wholly wanting, and such beds as do occur are thin, irregular and featureless. No rock exists which can be used as a horizon, so that the process of tying together the fragmentary local vertical sections is a painful one. But the cañons crossing or deeply indenting the field are numerous and are separated by narrow intervals; they afford ample opportunity for verification of the sections, and it seems hardly possible for serious errors to escape detection.

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* This is designated the Chicorica Mesa on Dr. Hayden's general map of Colorado.

The section of the group is approximately as follows:

1.	Great Sandstone,	440′
2.	*Coal bed* Z,	Blossom.
3.	Sandstone and shale,	77′
4.	*Coal bed* Y,	Blossom.
5.	Sandstone and shale,	75′
6.	*Coal bed* X′,	2′
7.	Shale and sandstone,	45′
8.	*Coal bed* X,	4′
9.	Sandstone and Shale,	26′
10.	*Coal bed* W,	6′ to 4″
11.	Sandst’e and Shale,	47′ to 70′
12.	*Coal bed* V,	4′ to 10″
13.	Sandst’e and shale,	30′ to 36′
14.	*Canadian coal bed* U,	6′ to 4″
15.	Sandst’e and shale,	20′ to 30′
16.	*Coal bed* T,	6′ to 2′ 6″
17.	Sandst’e and shale,	13′ to 20′
18.	*Coal bed* S,	4′ 3″ to 10″
19.	Sandstone and shale,	25′
20.	*Coal bed* R′,	1′ 4″
21.	Shale and sandst’e,	25′ to 35′
22.	*Caliente coal bed* R,	16′ to 1′
23.	Sandst’e and shale,	30′ to 35′
24.	*Raton coal bed* Q,	3′ to 1′
25.	Sandstone and shale,	25′
26.	*Coal bed* P,	2′ 6″ to 1′
27.	Sandst’e and shale,	40′ to 50′
28.	*Coal bed* O,	10″
29.	Sandstone and shale,	30′
30.	*Coal bed* N,	2′
31.	Sandst’e and shale,	33′ to 43′
32.	*Cameron coal bed* M,	33′ to 4″
33.	Sandst’e and shale,	22′ to 27′
34.	*Coal bed* L,	1′ to 8″
35.	Sandst’e and shale,	64′ to 70′
36.	*Coal bed* K,	3′
37.	Sandstone and shale,	24′
38.	*Coal bed* J′,	Blossom.
39.	Sandst’e and shale,	44′ to 52′
40.	*Long’s cañon coal bed* J,	8′ to 1′
41.	Sandst’e and shale,	45′ to 83′
42.	*Coal bed* I,	2′ 6″ to 2″
43.	Sandstone and shale,	50′
44.	*Coal bed* H′,	1′
45.	Sandst’e and shale,	50′ to 60′
46.	*Cat’s Claw Cañon coal bed* H,	5′ to 2″
47.	Sandst’e and shale,	90′ to 111′
48.	*Upper Vermejo coal bed* G,	2′ to 2″
49.	Sandst’e and shale,	60′ to 120′
50.	*Lower Vermejo coal bed* F,	9′ to 4″
51.	Shale,	12′
52.	*Coal bed* E″	1′
53.	Shale and sandstone,	15′
54.	*Coal bed* E′,	6″
55.	Shale and sandstone,	25′
56.	*Upper Reilly coal bed* E,	7′ 8″ to 2″
57.	Sandst’e and shale,	18′ to 31′
58.	*Lower Reilly coal bed* D,	6′ to 2″
59.	Sandst’e and shale,	12′ to 54′
60.	*Willow Creek coal bed* C,	3′ 6″ to 1′
61.	Sandst’e and shale,	76′ to 100′
62.	*Trinidad coal bed* B,	16′ 6″ to 1′
63.	Sandst’e and shale,	20′ to 45′
64.	*Dillon coal bed* A,	16′ 6″ to 1′
65.	Shale,	1′ to 10′
66.	Halymenites Sandstone,	50′ to 80′
67.	Shale and sandstone,	70′

The total thickness of the group, as shown in this field, is not far from 1800 feet.

The Coal Beds.

Several coal beds, which seem to be of very limited extent, have been omitted.

The beds given in the section appear to be persistent, being shown wherever their horizons are exposed; though often only by "blossoms," which sometimes fail to indicate either the thickness or the quality of the coal. No bed was found certainly wanting at any locality, except where, during the formation of some enormous sandstone, the underlying rocks, shales as well as coals, had been cut away. But, though thoroughly persistent, the Laramie coal beds are as variable as are those of the Lower Barren coal group of the Appalachian coal field. Reference to the section shows that no bed exhibits any degree of constancy, and that even the best one is at times utterly worthless. None possesses more than merely local importance. A bed, ten feet thick at one place, may be but a few inches thick at another only a mile away, or its excellent coal may be represented by wretched shale, utterly worthless for fuel.

The variations in thickness of the beds and in quality of the coal point to instability of conditions; but this is more clearly shown by the splitting up of the larger beds, especially in the lower part of the section; a most perplexing phenomenon, where readily identifiable horizons of sandstone or limestone are altogether absent. This subdivision of the beds seems to be confined to the lower part of the section, yet it may characterize the higher part also. The higher coal beds are seldom thick and their variations cannot be traced without much difficulty, the more so because their exposures are indistinct, being masked by debris of the sandstones.

The breaking up of the lower beds along the western edge of the field is so extreme, that at some localities the section of the first two hundred feet above the Halymenites Sandstone bears no resemblance to the same part of the group as exposed on the eastern side of the field. At the head of the Vermejo cañon, this interval contains fourteen streaks of *coal*, and black shales are liberally distributed throughout the section. The *Cameron coal bed* splits up into sixteen layers of sandstone, shale and coal, not far below Cameron post office on Vermejo creek in the center of the field. There the aggregate thickness is thirty-three feet, though but a short distance east or west, the bed is barely two feet thick. The most interesting variations are those shown by the *Trinidad coal bed*, between Trinidad and Raton Pass, within a distance of little more than nine miles. Four measurements gave the following results:

1. *Coal*,	0′ 8″	0′ 8″?	0′ 10″	4′ 0″
2. Interval,	7′ 0″	8′?	21′ 10″	24′ 0″
3. *Coal*,	1′ 8″	0′ 4″	3′ 0″	5′ 0″
4. Interval,	0′ 2″	0′ 4″	14′ 0″	13′ 0″
5. *Coal*,	5′ 0″	5′ 5″	6′ 0″	9′ 6″
6. Interval,	0′ 4″	1′ 4″	8′ 0″	12′ 0″
7. *Coal*,	2′ 0″	0′ 8″	1′ 0″	1′ 0″
Total,	16′ 10″	16′ 7″	54′ 8″	68′ 6″
Total of *Coal*,	9′ 10″	7′ 5″	10′ 10″	19′ 6″

The interval, No. 2, is filled with shale in the first two sections, but contains sandstone as well as shale in the last two. No. 4 is *bony coal* in the first two, but holds shale and sandstone in the last two. No. 6 is filled with clay at all of the localities.

The *coal* from the Laramie group in this field is soft. That from the *Trinidad bed* is excellent gas-coal and the slack is easily coked. The coking is done in bee-hive ovens similar to those used in western Pennsylvania. Little has been done, away from Trinidad, toward developing the mines. The whole country is cursed with old Mexican land grants, most of which are clouded, so that capitalists hesitate to make investments.

The Sandstones.

The sandstones are much alike and few of them are persistent. They change into shales and back again into sandstones in the most perverse manner. Still, some of these beds are constant and are serviceable locally as guides.

The Great Sandstone, closing the group within this field, is present at the summits of all divides and is readily recognized by its physical peculiarities. It is yellowish gray, compact, and for the most part comparatively fine-grained, though it occasionally contains a layer of not very coarse conglomerate. This rock is wholly non-fossiliferous at every locality where it was examined.

The sandstones above *coal beds* F, G and H, are usually present. These vary from light yellowish gray to decided buff. Ordinarily they are massive, but occasionally flaggy layers are found in which impressions of dicotyledonous leaves abound. No animal remains were observed except in the sandstone overlying *coal bed* F, in which obscure impressions of a *Cardium* were observed at one locality.

The *Halymenites sandstone*, at the base of the series, is comparatively fine-grained, usually gray, sometimes yellowish gray. It is invariably present and forms a distinct gray band on the bluffs from Cucharas Creek southward to Cimarron Creek, with the blossom of the *Dillon coal bed* almost immediately above it. I have given its name because the rock is loaded with *Halymenites major* Lesqx., which was not identified with certainty at any higher horizon within this field; though it is abundant at higher horizons in other fields farther north.

Almost without exception, the sandstones are fine-grained at the eastern edge of the field, but they become coarser toward the west, until on the western border, some of them are conglomerates and the shales have almost wholly disappeared. This condition exists at the base of the mountains.

Limestone layers were seen within several of the sandstones. They are always present on the eastern side of the field in the intervals between *coal beds* F and G, H and I, and I and J. Similar layers are sometimes shown in other intervals, but they are not persistent. These beds are from two to eighteen inches thick. None was found above *coal bed* J, which is about midway in the section. The limestone is blue to flesh-colored, weathers yellow because of much iron, and contains no fossils. It is very similar to much of the limestone found in the Lower Barren coal group of the Appalachian coal field.

Impressions of leaves of dicotyledonous plants were found in all the flaggy sandstones from the *Dillon coal bed* to the base of the Great Sandstone at the top of the section; but animal remains are rare. Some fish-teeth were obtained from the Halymenites Sandstone, associated with a *Cardium*, which is very similar to a shell of which imperfect impressions occur in the sandstone overlying the *Lower Vermejo coal bed.* But no impressions of leaves were found in the shales immediately overlying *coal beds.* The impressions occur only in sandstones; they are of isolated or fragmentary leaves and many of them were much softened by soaking before they were entombed. The plants belonged to upland vegetation and their leaves were evidently brought down to the shore by streams.

Relation of the Laramie to the Middle Cretaceous.

Throughout this southern coal-field the Lamarie rocks rest on the shales of the Fort Pierre sub-group, the Cretaceous, No. 4 of Mr. Meek's original section. These contain *Ammonites placenta*, *Baculites ovatus*, *Inoceramus convexus*, and other thoroughly characteristic species. The Fox Hills group, the No. 5 of Mr. Meek's section, appears to be wanting here. It certainly is wanting if the *Halymenites sandstone* is to be included in the Laramie group.

Lithologically, the transition from the Fort Pierre to the Laramie is so gradual that the line of separation between the groups must be assumed arbitrarily. The dark shales of the former pass upward into brownish shales with thin sandstones, which in turn shade away into the *Halymenites sandstone* above. The transition requires not far from two hundred feet of rock.

But a great change took place at the close of the Fort Pierre group. For the most part, the shales of that group are rich in animal remains, but such remains cease to appear at forty or fifty feet below the line assumed as the summit. Animal remains are, to all intents, absent from the Laramie group in the Trinidad coal-field. The newer conditions were unfavorable to animal life. Marine conditions, however, did not cease with the Fort Pierre. The sandstones of the Laramie are of marine origin, though perhaps only off-shore deposits. *Halymenites major* occurs profusely in the lowest sandstone within the Trinidad field as well as at much higher horizons in the Cañon City field. Huge knotted fucoids were found in a sandstone above *coal bed* J, in the former field. Other sandstones, showing no fucoids, contain many battered logs. Limestones, unmistakably of marine origin, occur up near to the middle of the Laramie. The change is not unlike that shown in the passage from the Lower to the Upper Carboniferous in the Appalachian coal-field.

ART. XXII.—*On some points in Lithology*; by JAMES D. DANA.

II. ON THE COMPOSITION OF THE CAPILLARY VOLCANIC GLASS OF KILAUEA, HAWAII, CALLED PÉLÉ'S HAIR.

THE capillary volcanic glass of Kilauea collected by the writer at the volcano in the year 1840 was analyzed for the writer's Geological Report of the Exploring Expedition (1849) by Prof. B. Silliman (B. Silliman, Jr.), and the results are published in it on page 200. The large discrepancies between the two analyses there reported—one of a dark and the other of a pale variety—and especially the difference as to soda, one being stated to contain 21·62 per cent, and the other none, left the question of composition in great doubt.* I have now to report two new satisfactory analyses of the glass. For these, science is indebted to Mr. F. J. Allen of the Sheffield Scientific School of Yale College, excepting the determination of the state of oxidation of the iron, which is by Prof. O. D. Allen. The results were as follows:

	I.	II.	Mean.
Silica	50·76	50·74	50·75
Alumina	16·68	16·39	16·54
Iron sesquioxide	2·15	2·05	2·10
Iron protoxide	7·90	7·87	7·88
Manganese protoxide	*trace*	*trace*	*trace*
Magnesia	7·65	7·65	7·65
Lime	11·95	11·97	11·96
Soda	2·11	2·16	2·13
Potash	0·55	0·57	0·56
Ignition	0·35	0·35	0·35
	100·10	99·75	99·92

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* The analyses also of volcanic scoria and lava, given on the same page of my Report, are evidently too uncertain to be longer quoted, unless the results shall be confirmed by other analysts.

The composition obtained has great interest, since it shows that this most fusible part of the Kilauea lavas has almost precisely the composition of ordinary doleryte (=basalt=diabase, essentially). I cite for comparison an analysis by G. W. Hawes of the "trap" of West Rock (New Haven, Conn.), which agrees closely with the average composition of this basic rock.

	SiO_2	AlO_3	FeO_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	ign
Pélé's Hair	50·75	16·54	2·10	7·88	*tr.*	7·65	11·96	2·13	0·56	0·35=99·92
West Rock "trap"	51·80	14·21	3·55	8·26	0·42	7·63	10·68	2·15	0·39	0·63=99·72

[+phosphoric acid 0·14

The "trap" consists of labradorite and augite with some magnetite. It is hence identical with the most abundant kind of igneous rocks. The fusibility of such a compound is thus well indicated by the facts at Kilauea. Moreover it is not surprising, since the fusibility of both labradorite and ordinary black augite are each marked down as low as 3 by von Kobell. There is hence no question as to the complete fusion of such ingredients in a volcano, even where moisture is not present.

The analyses add another to the many examples already known, proving that there was no difference in constitution between a large part of the material in fusion and ejected in Mesozoic time and that thrown out by modern volcanos; and it illustrates the fact that Geology has no good basis for the distinction of "older" and "younger" among igneous rocks.

An important paper on the microscopic characters of Pélé's Hair has been published at Tubingen (in 1877) by C. Fr. W. Krukenberg, in a pamphlet giving also the results of the author's investigations on Tachylyte and Hyalomelan, Basalt glass, Porous and Spherulitic Basalt, and Obsidian. He states, and illustrates by figures, the following facts respecting Pélé's Hair. The fibers are sometimes bent and coalesced into loops; often are tubular; frequently contain air bubbles, and occasionally microlites. There is usually an enlargement of the diameter whenever a crystal (or microlite) exists within, and also about many of the air-cavities. The crystals are mostly rhombic, but as to their kinds the author makes no suggestion.

ART. XXIII.—*On the size of Molecules;* by N. D. C. HODGES.

IF we consider unit mass of water, the expenditure on it of an amount of energy equivalent to 636·7 units of heat will convert it from water at zero into steam at 100°. I am going to consider this conversion into steam as a breaking up of the water into a large number of small parts, the total surface of which will be larger than that of the water originally. To increase the surface of a mass of water by one square centimeter requires the use of ·000825 milligrams of work. The total superficial area of all the parts, supposing them spherical, will be $4\pi r^2 N$. The number of parts being N, the work done in dividing the water will be $4\pi r^2 N$. For the volume of all the parts we have $\frac{4}{3}\pi r^3 N$. This volume is in accordance with the requirements of the kinetic theory of gases, about $\frac{1}{3000}$ of the total volume of the steam. The volume of the steam is 1752 times the original unit volume of water.

$$\text{Hence } \tfrac{4}{3}N\pi r^3 3000 = 1752$$
$$4N\pi r^2 \cdot 000825 = 636 \cdot 7{,}423$$

One unit of heat equals 423 milligrams.

Solving these equations for r and N, we get r equal to ·000000005 centimeter, a quantity of the same order of magnitude as has already been obtained by Thomson, Maxwell and others, N equal 9000 $(\text{million})^3 n$ for the number in one cubic centimeter 5 to 6 $(\text{million})^3$.

Around every body there is an atmosphere of more or less condensed gases. On the surface of platinum these must be nearly in the liquid condition, as shown by the power of platinum to bring the atoms of hydrogen and oxygen so near together that they combine. These vapors on the surface have a tendency at ordinary temperatures to expand; and part of them can do so, if the surface of the body is reduced. There is in these condensed atmospheres an explanation of all the phenomena of superficial tension. The energy in the unit of area ought to be equivalent to the amount of work done in compressing a quantity of the vapor from the gaseous to the liquid state sufficient to cover the surface a few molecules deep. The molecular attraction seems to be very slight in gases, when the molecules are ten or fifteen molecular diameters apart. To get some idea of the amount of work done in compressing one gram of oxygen to liquid form, we may consider that in the union of one gram of hydrogen with eight grams of oxygen 34,462 units of heat are produced. It matters not that the condensation is brought about by the energy of chemical separation rather than by the work done in pressing them together in a cylinder.

The superficial energy of platinum is 169·4 milligrams per square meter or ·01694 per square centimeter, equal to ·00004 of a unit of heat. The proposition

$$9 : 34{,}462 = x : \cdot 00004$$

gives the weight of water condensed on square centimeter of surface or the volume in cubic centimeters as ·00000001, which agrees with the other result.

Physical Laboratory, Harvard College, May 14, 1879.

ART. XXIV.—*Discovery of a new group of Lower Carboniferous Rocks in Southeastern Ohio;* by E. B. ANDREWS. Letter to the Editors dated Lancaster, Ohio, July 5, 1879.

I HAVE recently found in Perry County (Ohio) an interesting group of fossiliferous rocks between the Maxville Limestone (the approximate equivalent of the Chester group of Illinois), and the Waverly. In Illinois and along the Mississippi river, there are three distinct groups of Lower Carboniferous rocks between the Chester and the Waverly or Kinderhook of the Illinois Reports. These are the St. Louis, Keokuk and Burlington. It has long been my hope to find traces of these groups in Ohio. At one point I have recently obtained the following section:

Maxville limestone,	15 to 18 ft., estimated.
Coarse sandstone,	2 ft.
Clay shale, blue and red,	8 ft.
Horizon of nodular concretions, fossiliferous.	
Clay shale, blue,	7 ft.
Ferruginous limestone, highly fossiliferous,	15 in.
Blue clay shale,	8 to 10 ft.
Fine grained sandstone (Logan sandstone) Upper Waverly.	

At another locality, about a mile distant, I find the same intermediate group, but the Maxville limestone is not seen.

A few of the fossils first obtained were sent to Mr. R. P. Whitfield, who found them mostly new, but indicating a Keokuk type, with suggestions of Warsaw and Spergen Hill. I have since largely increased my collection and may have sixty or seventy species, and shall doubtless obtain many more. Besides corals and Bryozoa, which are beautifully preserved, I find representatives of the following genera: Lingula, Discina, Productus, Chonetes, Spirifer, Rhynconella, Phillipsia, Bellerophon, Aviculopecten, Platyceras, Dentalium, and of several others. Fragments of Crinoids are abundant, but, as yet, I I have found none whole. Very few of the species can be found in the underlying Waverly, and perhaps none in the overlying Maxville. I have been unable to identify many of the species with those figured in our Western Reports from the Lower Carboniferous rocks. It is probable that the newly found group does not exactly represent any of the groups found farther west, but shows the life that existed along the eastern shallow margin of the interior sea in which were deposited the vast calcareous beds of the Middle Lower Carboniferous, found along the Mississippi river. Provisionally the group may be called the Rushville group.

Art. XXV.—*Note on the Lower Waverly Strata of Ohio;* by EDWARD ORTON, Professor of Geology in Ohio State University, Columbus, Ohio.

THE Waverly Black Shale of Southern Ohio proves to be a very persistent stratum. It is but sixteen feet on the Ohio River, where it was first described by Professor E. B. Andrews, and at no point has it been found to exceed thirty feet in thickness, but it stretches without interruption from the Ohio River to Lake Erie, and now that it has been followed through the length of the State, it gives us the means of synchronizing the hitherto discordant elements of the lower part of the Waverly Group in a surprisingly satisfactory manner.

The identity of the Waverly Black Shale of Southern Ohio and the Cleveland Shale of Northern Ohio, which was suggested as probable ten years since by Dr. Newberry, and which has since been adopted by most of those who have written on the geology of the Waverly Group in Ohio, proves to be an error. Dr. Newberry has since shown that the Erie Shale wedges out as it is followed westward from Cleveland, letting the Cleveland Shale down upon the Huron Shale, near the mouth of Vermillion River. From this it would appear that the Black Shale that is followed southward from that point covers the interval occupied by three northern formations viz: the Huron, Erie and Cleveland Shales.

The Waverly Black Shale finds its place directly above the Berea Grit to the northward. The stratum has been distinctly described in the reports on the northern counties, but it has not been distinctly named. It has been treated of as the dark, fossiliferous shale at the base of the Cuyahoga Shale. No better name could be found for it than Berea Shale—for it makes the roof of the Berea quarries, just as it does of the lower Waverly quarries of Pike County.

As a result of this determination, it is seen that we have in the Berea Grit a stratum that can be traced continuously from the Pennsylvania line westward to Erie County, and from thence southward to the Ohio River. The equivalence of the several principal subdivisions of the series in Northern and Southern Ohio is now apparent. Thus we find that the Bedford Shale is the Waverly Shale of Pike County, the Berea Grit is the Lower Waverly of Central and Southern Ohio, the Berea Shale (base of the Cuyahoga Shale) is the Waverly Black Shale, and the Cuyahoga Shale of the northern counties is represented by just about the same measure and the same character of beds in Pike County that it has at the north.

At about four hundred feet above the Great Black Shale, certain highly fossiliferous beds occur. They have been worked for fossils quite carefully in Medina, Ashland, Licking, Ross, Pike and Scioto Counties. It seems probable, at least, that the Lodi, Ashland, Granville and Sciotoville fossils all come from the same horizon.

The Buena Vista Stone, that overlies by a few feet the Waverly Black Shale on the Ohio River, and with which the Berea Grit of Northern Ohio was identified by the erroneous reference of the Waverly Black Shale named above, proves to be much more local in its character than the other elements. It has not been found to hold as a continuous stratum as far north as the center of the State.

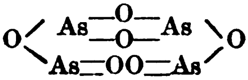
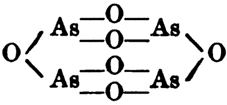
A summary of the facts here given is appended in a tabular form. The thickness of the several strata as found in Northern Ohio is that given by Dr. Newberry—while Southern Ohio is represented by the typical Waverly section.

Northern Ohio.	*Southern Ohio.*
Cuyahoga Shale, 150–250 ft. Upper beds fossiliferous.	Shale and Sandstone, 300–400 ft. Upper beds fossiliferous.
(Berea Shale,) 10 ft. Included by Newberry with Cuyahoga.	Waverly Black Shale, 15 ft.
Berea Grit, 60 ft.	Waverly Quarries, 60 ft. and overlying blue shale.
Bedford Shale, 75 ft.	Waverly Shale, 90 ft.
Cleveland Shale.	Great Black Shale.

A conglomerate covers the Cuyahoga Shale both in Northern and in Southern Ohio. It has been pronounced in both sections the Carboniferous conglomerate, but in Licking, Knox and other counties, the same fossiliferous stratum that underlies it constitutes the base of the Waverly conglomerate of Andrews, which is there separated from the Carboniferous conglomerate by one hundred to two hundred feet of the Logan sandstone of the same author. Without undertaking to clear up the confusion of the two conglomerates throughout the field, I venture to suggest that a satisfactory explanation for Southern Ohio seems to be found in the fact that upon the extreme western border of the coal-measures, the two conglomerates are unconformable by overlap, the Logan sandstone being greatly reduced and perhaps disappearing entirely, and the conglomerates thus coming to be considered as one.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Vapor-densities at very High Temperatures.*—**VICTOR MEYER** proposed some time ago a simple method for the approximate determination of vapor-densities for the purpose of fixing molecular weights.* Subsequently, in conjunction with **CARL MEYER**, he extended the method to the determination of densities at temperatures just below the softening point of Bohemian glass, finding the density of phosphoric sulphide P_2S_5 to be 7·65, theory requiring 7·67; and that of indium chloride to be 7·87, the formula $InCl_3$ requiring 7·60, thus proving indium to be a perissad. These authors have now rendered their method available for much higher temperatures, optically a bright yellow, lying between the fusing points of cast and of wrought iron, by the use of bulbs of porcelain, heated in a Perrot's gas furnace. The operation is conducted precisely as at lower temperatures, some details only requiring modification. The temperature of the muffle was determined calorimetrically by means of a block of platinum; giving 1570° C., 1543° and 1557° in three experiments, the mean being 1560°. Sulphur-vapor at this temperature, was found to have a density of 2·17, S_2 requiring 2·21. As Deville and Troost found 2·23 at 1040° C., S continues to be diatomic at higher temperatures. The density as found by the authors below redness, 6·58, corresponds to a hexatomic molecule, S_6. Cuprous chloride, also determined in nitrogen, gave 7·05, the formula Cu_2Cl_2 requiring 6·84. Arsenous oxide gave a density of 13·80 at a moderate red heat, 13·78 at 1560°; corresponding to the formula As_4O_6, which requires 13·68. This agrees with Mitscherlich's results and shows that the opinion of Kolbe that arsenous oxide would split up like sulphur, into smaller molecules at higher temperatures, is not correct, the formula being As_4O_6 alike at 571° and 1560°. Its constitution must therefore be either  or . Cinnabar gave a density of 5·39, the formula Hg_2S_2 requiring 5·34.—*Ber. Berl. Chem. Ges.*, xii, 1112, June, 1879. **G. F. B.**

2. *Vapor-densities of Metallic Chlorides.*—**VICTOR** and **CARL MEYER** give, in a later paper, the results of some determinations by their method, of the vapor-densities of certain metallic chlorides. Stannous chloride, at the temperature of 619° in a bath of melted lead, gave 12·85; at 697°, 13·08. Hence its formula should be Sn_2Cl_4 which requires 13·06. Zinc chloride, determined at 891° and 907° in the Perrot-Wiesenegg muffle furnace, gave 4·53

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* This Journal, III, xvii, 63, Jan., 1879.

and 4·61, $ZnCl_2$ requiring 4·70. Ferric chloride, in a lead bath heated to the boiling point of sulphur (about 447°) gave 11·14; and at 619°, 11·01, the formula Fe_2Cl_6 requiring 11·23. At higher temperatures, even at 697°, both ferric and aluminum chlorides lose chlorine.—*Ber. Berl. Chem. Ges.*, xii, 1195, June, 1879.

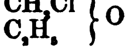
G. F. B.

3. *On Lead tetrachloride.*—FISHER has given some experimental evidence to prove the existence of a tetrachloride of lead. When lead dioxide is acted on by moderately strong hydrochloric acid, a yellow solution is obtained having a strong odor of chlorine, and easily decomposed by heat, evolving chlorine and depositing crystallized lead chloride. Alkalies and alkali carbonates, as well as earthy oxides and carbonates, throw down lead peroxide, as also do weak acids as acetic and boric. If no excess of hydrochloric acid is used, simple dilution with water precipitates the dioxide. For the analysis, lead dioxide was cautiously added to twice its weight of hydrochloric acid previously diluted with an equal volume of water. After a few minutes, the yellow solution was poured off from the precipitated lead dichloride. Twenty c. c. of this solution was allowed to flow into a solution of sodium acetate, producing a precipitate of lead dioxide. Twenty c. c. was also added to a definite volume of ferrous sulphate of known strength, in excess. The former mixture was then filtered into a Woulfe's bottle, the lead dioxide on the filter washed, dried, ignited and weighed. The latter solution was titrated with permanganate, the chlorine being estimated from the amount of the ferrous salt oxidized by it. Assuming the analytical reactions to be $PbCl_4+(H_2O)_2=PbO_2+(HCl)_4$ and $PbCl_4=PbCl_2+Cl_2$, it is evident that the lead obtained by the first of the above processes stands to the chlorine obtained by the second as 1 : 2 atoms. The experimental ratios obtained were 1 : 1·97, 1 : 2·03, 1 : 1·98, and 1 : 1·96, in several experiments; thus leaving no doubt that the yellow solution examined contained a compound of lead and chlorine in the proportion of one lead to four chlorine. The same body results when red lead is treated with HCl, and when chlorine gas is passed through a solution containing lead chloride in suspension. The facility of this conversion into peroxide in presence of sodium acetate leads the author to propose it as a quantitative method, using bromine in place of chlorine.—*J. Chem. Soc.*, xxxv, 282, June, 1879. G. F. B.

4. *On the New Element, Scandium.*—The new element scandium, discovered by Nilson, was obtained from a specimen of the ytterbia of Marignac, prepared from both gadolinite and euxenite. In order to ascertain whether the new element exists in both these minerals, or in only one of them, CLÈVE, engaged in the investigation of the gadolinite earths at the same time with Nilson, examined these especially for the new metal, and found, a few weeks after the discovery was announced by Nilson, that gadolinite contained it but only in minute quantity. From four kilograms of this mineral, he was able to extract 0·8 gram scan-

dium oxide; hence he infers that gadolinite contains 0·02 per cent of this earth. In studying the yttric earths of yttrotitanite or keilhauite from Arendal, he found scandia present there also. Three kilograms of this mineral gave him 1·2 grams of scandium oxide, corresponding to 0·04 per cent. He is now engaged on larger quantities of the keilhauite and hopes to obtain enough material to enable him to determine the more important characters of the new element, which he thinks does not belong to the yttrium group.—*Bull. Soc. Ch.*, II, xxxi, 486, June, 1879.

G. F. B.

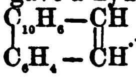
5. *On the Action of Bleaching Powder on Ethyl Alcohol.*—Schmitt and Goldberg have studied the action which goes on in the commercial process for the preparation of chloroform by distilling together bleaching powder and ethyl alcohol. When a good bleaching powder acts on absolute alcohol, after seven to ten minutes an energetic reaction sets in with evolution of much heat, and there distills over, besides the excess of alcohol, a greenish yellow oil, which under the influence of light and heat decomposes almost explosively, evolving vapors of hydrochloric and hypochlorous acids. They have not succeeded in isolating this oil, but they believe it to be ethyl hypochlorite, formed by the reaction: $CaCl_2 + Ca(OCl)_2 + (C_2H_5OH)_2 = CaCl_2 + Ca(OH)_2 + (C_2H_5(OCl))_2$. The residue of the distillate after the explosion, consists about $\frac{4}{5}$ of alcohol and aldehyde, removable by water, and about $\frac{1}{5}$ of a non-miscible oil, heavier than water. Forty c.c. of this oil, obtained by the use of 415 c.c. alcohol, gave, on fractioning, 1 c.c. boiling below 70°, 4 c.c. between 70° and 80, 5 c.c. between 80° and 100°, 8·5 c.c. between 100° and 150°, 20·5 c.c. between 150° and 160°, and 1·5 c.c. between 160° and 180°. The largest fraction yielded a constant product boiling at 154°–155°, which was monochloracetal. The highest fraction gave dichloracetal. The fraction from 80° to 150° gave a product constant at 77°–78° which gave the formula C_3H_7OCl, probably chlormethylethyl ether  $\left.\begin{matrix}CH_2Cl\\ C_2H_5\end{matrix}\right\}O$.—*J. prak. Ch.*, II, xix, 393, May, 1879.

G. F. B.

6. *On Heptane from Pinus Sabiniana.*—Thorpe has submitted to examination a hydrocarbon obtained by distilling the exudation of a Coniferous tree, *Pinus sabiniana* Dougl., or nut pine, growing in the Sierras of California. This hydrocarbon was first described in 1871 by Wenzell of San Francisco under the name "Abietene," it being found in commerce under the names abietene, erasine, aurantine, theoline, etc. Through the assistance of Dr. Squibb of Brooklyn, Thorpe obtained two gallons of this hydrocarbon from Wenzell. Its physical properties fully confirmed the statements of the latter. It was colorless, had a persistent odor of oil of oranges, boiled slightly below 100° and left a resin, which had the above odor very strongly. On agitating the oil with strong sulphuric acid, the acid became brown and the hydrocarbon lost its smell. Its boiling point, corrected, was

found to be 98·43° and 98·42° in two portions. On analysis it gave 83·81 carbon, 16·05 hydrogen, while heptane C_7H_{16} requires 83·97 carbon, 16·03 hydrogen. Its vapor density was found to be 50·07 and 49·94 in two experiments, C_7H_{16} requiring 49·90. Having so large a quantity of pure heptane, Thorpe undertook the determination of its physical constants. Three determinations of its specific gravity, reduced to 0° and referred to water at 0°, gave 0·70057. The coefficient of expansion between 0° and 100° is given by the formula $1 + 0{\cdot}00121023t + 0{\cdot}0000011133t^2 + 0{\cdot}000000001174t^3$. The volume at the boiling point 98·43°, is 1·14111. The specific gravity at this temperature is 0·61393 and its specific volume is 162·54, that calculated from Kopp's values being 165. Its refractive index was found to be 1·3879 at 17·6° for the sodium line. The specific refractive energy $\frac{\mu-1}{d}$, is 0·565; and its molecular refractive energy is 56·4, the value from Landolt's formula being 55·8. It appears to have a slight rotatory power +6·9′. Its coefficient of viscosity varies with the temperature, the value being given by the formula $\eta = 0{\cdot}005003 - 0{\cdot}00005501t + 0{\cdot}0000003061t^2$. Its surface tension by the capillary tube method was found to be 22·19 C. G. S. units; and by the bubble method 21·8 and 21·12 units; giving 167 as the angle of capillarity. This surface tension is the lowest of any known liquid. Thorpe believes that this heptane is probably isomeric with that obtained from petroleum and probably identical with that from azelaic acid.—*J. Chem. Soc.*, xxxv, 296, June, 1879. G. F. B.

7. *On the Synthesis of Chrysene.*—GRAEBE and BUNGENER, struck by the similarity between chrysene and phenanthrene, formulated them analogously and suggested that the former might be a phenyl-naphthalene derivative, as the latter is a diphenyl one. By the action of Al_2Cl_6 upon a mixture of phenyl-acetic acid and naphthalene, benzyl-naphthyl ketone was obtained. This reduced by HI and P, and the product passed through an ignited tube gave a hydrocarbon identical with chrysene, having the formula



$$\begin{array}{l} C_{10}H_6-CH \\ \Big| \qquad\quad \Big\| \\ C_6H_4-CH \end{array}$$

.—*Ber. Berl. Chem. Ges.*, xii, 1078, June, 1879. G. F. B.

8. *Modern Chromatics, with applications to Art and Industry;* by OGDEN N. ROOD, Professor of Physics in Columbia College. 329 pp. 8vo. New York, 1879. (International Scientific Series—D. Appleton & Co.)—The very difficult task of presenting the principles of Optics so as to make them thoroughly intelligible to the reader has been admirably accomplished by Professor Rood in his work on Modern Chromatics. The work contains a discussion of the different ways by which colors are produced; the theory of color (that of Young); mixture of colors; complementary colors; and an account of the many effects produced by the combination and contrast of different colors. A closing chapter is devoted to the use of color in painting and decoration; it contains—what is indeed true of the whole work—much that will

be of high value to the artist, from one who has himself the great advantage of a practical knowledge of both drawing and painting. The book is largely made up of the results of the author's own investigations, which give it a character of its own; and it contains a large number of original illustrations.

9. *Color-blindness: its dangers and its detection;* by B. Joy Jeffries, A.M., M.D. 312 pp. 8vo. Boston, 1879. (Houghton, Osgood & Co.).—The subject of Color-blindness is one of not only very general interest, but of a high degree of practical importance, since many accidents on land and sea have resulted from misreading signals consequent on the imperfect vision of employés. The important work of Professor Holmgren published at Upsala, Sweden, in 1877, and soon afterward translated into French, first thoroughly developed this subject and made known its great importance. Dr. Jeffries has extended his investigations among the students of the various institutions of learning near Boston and Cambridge, embracing some 18,000 examinations, and the results are contained in this volume. It contains also a discussion of the whole subject, with particular instructions in regard to the use of Holmgren's method of testing for color-blindness. In his general conclusions, Dr. Jeffries states that:—one male in twenty-five is color-blind in a greater or less degree, though he may be himself unconscious of the defect; moreover, though sometimes caused temporarily or permanently by disease or injury, it is largely hereditary, and in that case is incurable. He also recommends that rigid and uniform proof of soundness of vision should be required of every employé in the railway or marine service.

10. *Friction and Lubrication: determinations of the laws and coefficients of friction by new methods and with new apparatus;* by R. H. Thurston, A.M., C.E. 212 pp. 8vo. New York, 1879. —This work treats of the kinds of friction, and the different ways in which it arises in the use of machinery; also of the kinds of lubricants, and the methods of determining their value, with a full discussion of their composition. It also contains descriptions of new methods and apparatus, devised by the author, for the determination of the laws and coefficients of friction. The work will be of much value to the mechanical engineer.

11. *Neuere Apparate für Naturwissenschaftliche Schule und Forschung*, gesammelt von M. Th. Edelmann. I. Lieferung, 96 pp. 8vo. Stuttgart, 1879 (Meyer & Zeller's Verlag).—This work is to be complete in three parts, of which the first is now issued. It contains descriptions of the newest and most complete apparatus, designed either for instruction in the lecture room, or for actual scientific investigations. The scope of the work is a wide one, and it will be found useful by physicists, chemists, physiologists, astronomers, and those working in many other branches of science. The descriptions are full and precise, and in many cases are accompanied by full-page illustrations which much increase the value of the work.

II. GEOLOGY AND MINERALOGY.

1. *The Auriferous Gravels of the Sierra Nevada of California;* by J. D. WHITNEY. Vol. vi, No. 1 (1st Part) of the Memoirs of the Museum of Comparative Zoology at Harvard College. 288 pp. 4to, with colored maps and plates. Cambridge, 1879.—This volume belongs strictly to the series of Reports of the Geological Survey of California, of which Professor Whitney was Director;—and the value and variety of its facts and discussions give reason for continued regret that the Survey came so abruptly to its end through the failure of the State to sustain it. Professor Whitney has continued since to some extent his investigations; and happily he has found in the Museum of Comparative Zoology at Harvard the aid required for the publication of this new volume; and aid most liberally given, for the volume is brought out in the best style, with several heliographic plates, and a number of colored maps, one of them a large sheet folded.

The First Part presents first a sketch of the topography and general Geology of the region of California, as a basis for the discussion of the main topic of the work—the Auriferous Gravels, this being necessary because these were made out of the earlier rocks, and owe their distribution and wonderful extent to the features of the surface. The sketch is brief, yet clear and full, and, considering the many peculiarities in the mountains and strata of the country, and the masterly manner in which the facts are set forth, these pages have no less interest to the geologist than those which follow. Only the more prominent peculiarities of the Sierra Nevada are here cited.

(1) Its singleness of mass, unlike the Coast Range and Appalachians, which consist of many prominent ridges.

(2) Its defined limits—a single broad valley, narrowing northward, that of the Sacramento and San Joaquin Rivers, bounding it on the west; but blending with the Coast Range on the north in the vicinity of Mount Shasta, and bending westward into them south of the parallel of 35° 30′.

(3) Its steep slopes, generally 100 to 250 feet to the mile on the western side, and 1,000 feet a mile for much of the eastern side.

(4) Its profound gorges, like gashes in the steep sides, in which the streams flow violently in seasons of great rains, though quiet enough in the much longer seasons of drought.

(5) Its great height, numerous peaks exceeding 14,000 feet in altitude above the sea-level, but none quite reaching 15,000 feet: the greatest height being between the parallels of 36° and 37° 30′.

(6) Its granitic axis, widening southward, granite making nearly the whole of its mass north of the Tahichipi Pass almost to Mariposa County, but north of this narrowing, and the schists (clay-slate, mica schist, chloritic and diabase schists, with some serpentine and limestone, mostly of Triassic and Jurassic age, and nothing older than Carboniferous), constituting much of the range

on the west side; while north of American River they constitute nearly the whole width, only occasional areas of granite occurring along the crest and on the eastern slope; and little of the granite gneissoid.

(7) Its outflow of igneous rocks, which spread over the gravel deposits of much of the western slope in the several counties from Mariposa to Plumas, increase in extent in Butte and Plumas Counties, and cover nearly the whole of the surface north of Plumas from Lassen's Peak, a volcanic cone 10,500 feet high, on the northern boundary of this county, the Sierra being prolonged thence in a series of volcanic cones which culminates in Mount Shasta.

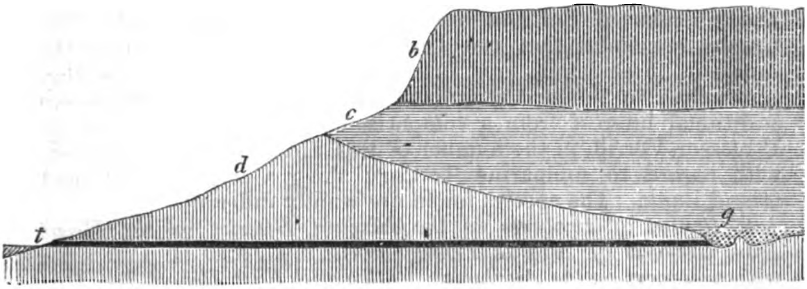
The Auriferous gravels exist over most of the western slope and are worked from Mariposa County into Plumas, or northward to the limit where the volcanic covering becomes general, and southward to that where granite is the chief rock. El Dorado, Placer and Nevada are the great mining counties. In the granitic regions of the Sierra the gravels are local in character, and, with small exceptions, not worked.

The schists, with their quartz veins, are the source of the gravel and its gold. Professor Whitney attributes the deposits to the action of the rivers of the later Tertiary and earlier time. He says, they "belong to a system of ancient rivers in the former beds of which detrital matter has been deposited, and which have since become in part obliterated by accumulations of lava, and extensively worn away by erosion." At present, the rivers and gorges are cut to a depth of many hundreds of feet below the surface either side. Starting from the foot-hills, the level of the surface between the streams rises much faster than the beds of the streams, so that when up 3,000 to 4,000 feet, the cuts are in many cases 1,000 to 2,000 feet deep. Further, there is a great difference between the level of the present beds and those of the era in which the gravels were deposited; this difference being 1,800 feet in the Middle Fork of American River at Michigan Bluff, 1,300 feet at Iowa Hill, on the divide south of the North Fork of the American. These cañons increase in depth to the north of the South Yuba: the difference of level between the Middle Fork of Feather River at Nelson's Point and the summit of the lava-bed of Pilot Peak which overlies the gravel being fully 3,650 feet; between the top of Mount Clermont, which is topped with gravel, and the valley at its base, 3,750 feet; between the top of Spanish Peak, which is capped with lava and gravel, and the valley of American River, 3,800 feet.

"An excellent idea of the topography of the hydraulic mining region is got by the traveler passing over the line of the Central Pacific Railroad, in descending the slope of the Sierra. After passing Blue Cañon, the slates begin to be met with, and all along below this, especially in the neighborhood of Dutch Flat, and beyond that for several miles, the road passes through a region of hydraulic mines, keeping on what seems to be a broad plateau, which has an elevation of a little over 3,000 feet above the sea-level. Suddenly, just before reaching Colfax, a sharp bend in the line, at a place called Cape Horn, brings the road bed just on to the edge of the cañon of the North Fork of the American, down into and along which there is an unobstructed view for eight or ten miles, the bottom of the cañon being about 1,600 feet below the level of the road. The effect of the scene presented to the eye from this point is extremely striking, because the spectator has not been prepared, by anything which he has previously seen, to expect to find the flanks of the Sierra so deeply cut into by the streams, which seem of insignificant size as compared with the immense troughs at the bottom of which they run."

The course of the old channels are but partially made out. They are the objects of search by the miner, since the richer auriferous gravels lie along them, directly upon the bed rock. But although often of great depth and distinctness, they are only partially uncovered in the mining operations, and the facts are not examined and recorded when open to view, so that "we can never expect to know exactly what were the relations of the various parts of the old river system to one another." The lava-floods and beds of volcanic ashes and other material over the gravels prevent even the miner from exploring a large part of the old surface, though hydraulic mining and tunnelling have been pushed with great energy where it would pay. The volume gives a detailed account of observations on the gravel deposits and the bed-rock made for the Survey (on appointment of Professor Whitney) by Mr. W. A. Goodyear and Professor W. H. Pettee, which are illustrated by colored maps of the areas of lava and gravel.

Because of its special interest we copy here one of the sections of the Sonora, or Tuolumne County, Table Mountain, from Plate



F. It represents (on a scale of 300 feet to the inch) the cap or table-top of basalt (*b*) over 200 feet thick, overlying sand-beds and shaly material (*c*), with an auriferous gravel deposit (*g*) at the lowest part, and these resting on the nearly vertical metamorphic schists (*d*). The surface of the schists rises to the left, making there the "rim" of the old channel; and a tunnel (*t*) is represented passing through this rim to the gold-bearing gravels, a common method of search, though attended with large expense and not always successful.

A notice of the fossils of the gravels, including its Human relics, is deferred to another number.

2. *Richthofen's Theory of the Lœss, in the light of the Deposits of the Missouri;* by J. E. Todd, of Tabor, Iowa.—This memoir, read before the last meeting of the American Association, is a strong argument, well-sustained by facts drawn mainly from the region of the Missouri River, against the wind-drift theory of the lœss. The writer observes that although the mollusks are mainly terrestrial, "some semi-aquatic species, as *Succineas* and *Helicinas* are abundant from top to bottom [in the lœss of the Missouri], and the decidedly aquatic *Limnea humilis* is quite abundant in the Upper lœss of Western Iowa." Further, "the small size of the *Limneas* and absence of *Physas* in the latitude of Iowa, may be considered as indicating that the waters were cold, while the occurrence of numerous land-shells of species still inhabiting the region, indicates that the lands were more moist with their temperature not differing greatly from the present." Root-marks occur in much of the lœss but are mostly confined to its upper portion, being rare at a depth exceeding thirty or forty feet.

3. *Tertiary in Massachusetts Bay.*—Many fossiliferous bowlders have been found by Mr. Warren Upham, as reported by Mr. W. O. Crosby in the Proceedings of the Boston Natural History Society for February last, at different points in the Drift of Truro on Cape Cod. They include *Venericardia planicosta,* a Lower Eocene species of Virginia, and two others of the same genus, one probably *P. parva,* described by Lea, from Alabama, three species of Ostrea, one apparently *O. divaricata* Lea, of the Alabama Middle Eocene, an Anomia which is probably *A. tellinoides* Morton, a *Plicatula* near *P. filamentosa* Conrad, of the Alabama Eocene, besides several other species of shells, and remains of Echinoderms and a Galaxea-like coral. Mr. Crosby concludes that the Tertiary formation, which was the source of these fossils, now forms the floor of Massachusetts Bay somewhere to the northward of Cape Cod. These facts derive additional interest from a comparison with those announced by Professor Verrill, in the number of this Journal for October last, with regard to submarine Tertiary along George's Bank and Grand Bank. The species found are wholly different.

4. *Report of Progress in the Juniata District on the Fossil Iron Ore-beds of Middle Pennsylvania,* by John H. Dewees; with a *Report on the Aughwick Valley and East Broad Top District,* by C. A. Ashburner. Second Pennsylvania Geological Survey. Harrisburg, 1878.—This Report is noticed by title only on page 262 of the last volume of this Journal. It opens with a Preface by Prof. Lesley, Director of the Survey, giving a general sketch of the formations in which iron-bearing beds occur, the most important of which are those of the Clinton group, and the Marcellus. Mr. Dewees presents the facts with full details of the stratification. Excellent sections of the folded rocks are given

which are by Mr. Ashburner, and are continued in his portion of the volume; and these are supplemented by large and fine colored sections and maps in a portfolio. This geologist, moreover, describes the Silurian and Devonian rocks from the Trenton to the Hamilton in the valley of the Juniata, from Lewistown in Mifflin County to Mount Union in Huntingdon County; and the account has special interest since it illustrates the typical structure of Central Pennsylvania. A carefully measured section from the bottom of the Trenton to the top of the Mahoning Sandstone, or top of the Lower Productive Coal measures, shows a thickness of 18,397 feet—and in this long section, 68·9 feet is the average thickness for the 267 separate strata included. A catalogue of specimens, and another of heights above the sea-level are given, in an Appendix to the Report. The former is on a plan worthy of imitation. Mr. Ashburner places on the labels of his specimens (besides the geographical position) the number of the stratum, the distance in feet from the lower limit of the same, and also the dip of the beds; so that any future investigator will be able to take up any part of the work for revision or for further study.

5. *On the Geology of Gibraltar.*—The following facts are from a paper by Professor A. C. Ramsay and James Geikie, in the Quarterly Journal of the Geological Society for August, 1878.—More than three-fourths of the promontory of Gibraltar consists of a grayish white bedded limestone, containing occasional casts of Rhynchonellæ and encrinal stems, the former closely like *R. concinna*, a species abundant in the Cornbrash and Coral Rag. The limestone is overlaid by shales of various shades of color, with some thin calcareous beds, which have afforded no fossils. The dip of the rocks is in general over 40°, and in some parts 75° and higher. Upon these beds there are superficial deposits. The oldest is a limestone breccia, covering a large area in the district of Buena Vista and Rosia, and in the vicinity of the South Barracks; it is unfossiliferous. The authors attribute the origin of the limestone fragments of which the breccia consists to the frosts or cold of the Glacial era. The mean temperature of the coldest month (February) is now 54·2°, and the lowest point reached in the six years from 1853 to 1859 was 32·7°; and no debris is now forming from such a cause or any other. Besides these surface breccias or conglomerates there are also bone-breccias in caves and fissures. The famous bone-breccia at Rosia Bay occupies a vertical fissure of erosion in the above-described surface breccia, while the Genista breccia occurs in a true cave.

The promontory bears evidence of different sea-levels in terraces or platforms cut in the solid rock, surmounted sometimes by calcareous sandstones. The Europa Flats is one of these sea-levels on the southern portion of the promontory; it extends from west to east for 1650 feet, and it averages 115 feet above the sea-level, though sloping up from 90 feet to 150 feet. It appears also at other points. The calcareous conglomerate over it contains some remains of Mediterranean species and is evidently of marine shore origin. Another such terrace has a height not less than 250 feet; a third, about 830 yards in length and over 330 broad, is 370 feet above the sea. In the front of the same cliffs at a height of 170 feet an oyster-bed was formerly visible.

Among the species of Mammals identified by Messrs. Busk and Falconer from the Genista cave, there are *Rhinoceros hemitœchus*, *Horse*, *Boar*, *Cervus elaphas*, *C. dama*, *Ibex*, *Bear*, *Wolf*, *Hyæna crocuta*, *Lion*, *Panther*, *Lynx*, etc., and these authors concluded that, at the time these animals were living, Europe and Africa were at some point united across the Mediterranean. With this in view, the succession of Quaternary events in Gibraltar is given as follows:

(1.) *Great unfossiliferous limestone-agglomerate of Buena Vista, etc.*—Land of greater extent than now; winters very cold; Gibraltar apparently not tenanted by the Quaternary Mammalia.

(2.) *Caves and fissures with bone-breccia.*—Land of greater extent than now; Europe and Africa united; climate genial; immigration of the African Mammalia.

(3.) *Platforms or terraces of marine erosion (in part), calcareous sands, etc.*—Depression of the land to the extent of 700 feet below present level; movement interrupted by pauses of longer or shorter duration; climate apparently much the same as now.

(4.) *Platforms of marine erosion (in part); Alameda Sands; formation of sand-slopes on east coast, as at Monkey's Cave; mammalian remains under beach or later limestone-agglomerate (perhaps cave-deposits in part).*—Reëlevation; land of greater extent than now (Africa and Europe perhaps reunited); climate probably genial.

(5.) *Later limestone-agglomerates resting upon and obscuring erosion-terraces and sand-slopes, etc.*—Geographical conditions probably same as during part of 4; winter considerably more severe than now.

(6.) *The present.*—Characterized by the absence of the action of frost.

On the conclusion of the reading of the paper, the statement was made by Admiral Spratt, that to the westward of Farifa Point a submarine ridge exists which nowhere exceeds 130 fathoms in depth; so that an upheaval of about 800 feet would connect the two continents by dry land.

6. *Etudes Synthétiques de Géologie Expérimental*, par A. Daubrée, Membre de L'Institut, Inspecteur Général des Mines, etc. Première Partie, *Application de la Méthode Expérimentale a l'étude de divers Phénomènes Géologiques.* 478 pp. 8vo. Paris, 1879. (Dunod).—The admirable researches in Experimental Geology of Professor Daubrée have in part been briefly announced in former volumes of this Journal. The work just issued under the above title contains these results in full, and, in addition, those

of more recent researches. After a historical introduction, the author gives an account of his observations illustrating the history of metalliferous deposits, and especially those of tin, lead and platinum, bringing in a wide range of facts relating to such deposits, and among them prominently his remarkable discoveries of a large number of ores of modern formation made out of a lot of Roman coins at the Warm Springs of Bourbonne-les-Bains, and also of similar formations at some other localities; and, after stating the facts, the chemistry of the phenomena and the geological inferences from the facts are learnedly presented.

Professor Daubrée's next subject is Experimental illustrations of the origin of metamorphic and eruptive rocks. Under this head numerous observations are reviewed, and in addition the results of his own experiments, with regard to the formation of silicates by means of superheated water: such as the transformation of glass into a hydrated silica and crystallized quartz, the glass sometimes containing minute well-formed crystals of pyroxene (figures of which crystals as well as of those of quartz are given); and the formation of zeolites (chabazite, apophyllite, etc.) at Plombières, and at other warm baths inside of bricks, along with opal, chalcedony, tridymite, aragonite, and other species. Volcanic phenomena are next illustrated by experiments, and with this chapter the first section of the volume closes. The second section is occupied with mechanical problems: (1) the making of sand-beds and clay-beds, showing for example, the effects of the trituration of feldspar in water (some loss of alkali taking place in pure water and "incomparably less" with salt water), in carbonated waters, etc.; (2) the scratching and polishing of rocks, their flexures, fractures, faults, jointed structure, slaty cleavage and schistosity, and the distortions of fossils and pebbles; and (3) the production of heat in rocks by mechanical methods. All the modes of experimenting are described in detail, and illustrated by figures; many of the results obtained in his mechanical processes are also figured, and their bearings on geological problems are fully and ably discussed. The work is thus in every part a rich contribution to the science of geology; moreover it is made highly attractive by its style of publication and the beauty of its illustrations.

7. *Rocks under London.*—In the Artesian boring in the Tottenham Court Road, according to a paper by Professor Prestwich (Quart. J. Geol. Soc., Nov., 1878), it was found that the Chalk had a total thickness of 652½ feet, the Upper Greensand 28 feet, the Gault 160 feet. Below this was a bed three to four feet thick of phosphatic nodules and quartz pebbles; and then a calcareous stratum, more or less sandy, and part of it oolitic, sixty-four feet thick, which was shown by its fossils to represent the Lower Greensand. Underneath, at a depth of 1064 feet, the bore-hole entered mottled red, purple and greenish shales, to some extent calcareous, having a dip of 35°, and these continued for eighty-five feet; they afforded the fossils *Spirifer disjuncta*, *Rhynchonella cuboides*, and other Devonian species. The rocks

resemble those of Pernes, near Bethune, where the chalk rests on the upturned Devonian. Professor Prestwich attributes the calcareous character of the Lower Greensand to the Paleozoic limestones on which it rests.

8. *Fossils of the Utica Slate and Metamorphoses of Triarthrus Becki*, by C. D. WALCOTT. Trans. Albany Institute, June, 1879. —Mr. Walcott, after remarks on the Hudson River Group, describes, from the Utica Slate, three new species of Fucoids, five of Graptolites, *Modiolopsis cancellata* and *Orthoceras Oneidaense;* and then gives, with much detail, an account of the synonymy and metamorphoses of *Triarthrus Becki* which is illustrated by sixteen figures. The smallest individual of the species described and figured has only one thoracic segment and a length of but 1·125 mm., and the largest a length of 53 mm. In the former the pygidium is very nearly as long as the head segment, and in the latter it is one-third as long. The memoir closes with a table of Utica slate fossils showing their stratigraphical range.

9. *New Calciferous fossils from Saratoga County, New York.* —Mr. C. D. Walcott has described as new the following species: *Platyceras minutissimum*, *Metoptoma cornutiforme; Conocephalites calciferus*, *C. Hartii*, *Ptychaspis speciosus.* *Bathyurus armatus* of Billings (from the Quebec group), or a form closely related, also occurs in the beds.—32*nd Ann. Rep. N. Y. Mus. Nat. Hist.*

10. *Fossil wood related to Cypress from Calistoga, California.* —H. Conwentz, of Breslau, has published in the Jahrbuch für Mineralogie, etc., for 1878, a description, with microscopic sections, of a fossil wood from Calistoga, which he has named *Cupressinoxylon taxodioides.*

11. *Erdbeben-Studien* von R. HŒRNES.—After a general discussion of earthquake phenomena, Hœrnes describes in detail the earthquake of Belluno, of June 29, 1873, that of Klana (near Trieste) of March, 1870, and also that of Villach in 1348. The conclusions which are finally reached are stated as follows: (1) Shakings of the earth are produced by various causes: sometimes, though rarely, by the tumbling in of subterranean caves; also, though only locally, by volcanic force; but the true earthquakes, those of most frequent occurrence and greatest extent, are a direct consequence of mountain formation. (2) On the inner side of a great mountain chain, earthquakes take place along peripheral lines of fracture which are shown by the progression of the points of shock. These disturbances seem to be produced by the sinking of the inner zones to true fault-fractures. (3) Besides the peripheral zones of shaking, there exist on the inner edge of the chain, radial lines, coinciding with cross-fractures on which severe earthquakes often occur. These radial lines very probably are to be regarded in part as the boundaries of masses occasionally involved in sinking, and in part also as the line of separation of two regions undergoing a horizontal movement. (4) Between the peripheral and radial lines no sharp limit can be drawn, since the

boundary of a region of depression is very irregular; moreover the continuation of the cross-fracture not unfrequently coincides with the longitudinal fractures, and *vice versa.* (5) The connection of the seismical lines of different dynamical value is most readily explained by the assumption that a portion of the earth's crust gives its motion to another, and this makes itself felt by the shakings along the course of a fracture.—*Jahrb. k. k. geol. Reichsanstalt*, xxviii, p. 387, 1878. E. S. D.

12. *Examination of the North Carolina Uranium minerals;* by F. A. Genth (American Chemical Journal, vol. i, p. 87).—The uranium minerals of North Carolina were first described by Professor W. C. Kerr (this Journal, III, xiv, 496, Dec., 1877). As stated by him, they occur as irregular nodules and rounded masses in the mica-bearing portion of a large granite vein; the locality is called the Flat Rock mine. Dr. Genth has subjected the minerals to a thorough chemical examination, and in the main confirmed the determination of the species made by Professor Kerr. The masses contain, in many cases, a nucleus of uraninite; surrounding this is an orange-colored mineral, gummite; and interpenetrating it and forming a crust over it, a light yellow mineral, identified by Dr. Genth as uranotil. The uraninite occurred in too small a quantity to allow of its being analyzed. The *gummite* has a compact, amorphous structure; reddish-yellow to deep orange-red color; and subconchoidal to uneven fracture; with hardness = 3; and specific gravity = 4·840. The mean of three analyses gave:—

UO_3	$\text{Ⱥ}lO_3$	PbO	BaO	SrO	CaO	SiO_2	P_2O_5	H_2O
75·20	0·53	5·57	1·08		2·05	4·63	0·12	10·54=99·72.

Dr. Genth regards the gummite as a mechanical mixture of:—

Uranium hydrate $= H_2(UO_2)O_2 + H_2O =$ 40·10 p. c.
Uranotil $= Ca_3(UO_2)_6Si_6O_{21} + 18H_2O =$ 33·38 p. c.
Lead uranate $= Pb(UO_2)_2O_3 + 6H_2O =$ 22·66 p. c.
Barium uranate $= Ba(UO_2)_2O_3 + 6H_2O =$ 4·26 p. c.
100·40.

The pale yellow coating surrounding the gummite has been identified by Dr. Genth as *uranotil*, a mineral originally described by Boricky from Wölsendorf, Bavaria. As occurring in North Carolina it is amorphous, compact; hardness = 2·5; specific gravity 3·834; color pale straw-yellow to lemon-yellow; luster waxy to dull. The mean of two analyses gave:—

SiO_2	$\text{Ⱥ}lO_3(\text{Ꞙ}lO_3)$	UO_3	PbO	BaO	SrO	CaO	P_2O_5	H_2O
13·75	*tr.*	66·67	0·60	0·28	0·13	6·67	0·29	12·02=99·43

For this the formula $Ca_3(UO_2)_6Si_6O_{21} + 18H_2O$ is suggested, which requires: SiO_2 13·95, UO_3 66·98, CaO 6·51, H_2O 12·56 = 100·00.

In addition to the above, autunite has been found at the locality and, associated closely with it, a new species called by the describer *phosphuranylite.* It occurs as a pulverulent incrustation on quartz, feldspar and mica. Under the microscope very minute rectangular scales with pearly luster were distinguished.

Color deep lemon-yellow. An analysis gave: P_2O_5 11·30, UO_3 71·73, PbO 4·40, H_2O 10·48=97·91. The lead is regarded as being present as cerussite; if this is deducted the result becomes: P_2O_5 12·08, UO_3 76·71, H_2O 11·21=100. The formula obtained is $(UO_2)_3P_2O_8+6H_2O$, which requires: P_2O_5 12·75, UO_3 77·56, H_2O 9·69=100. E. S. D.

III. BOTANY AND ZOOLOGY.

1. *Report upon U. S. Geographical Surveys west of the* 100*th Meridian, in charge of First Lieut.* GEO. M. WHEELER, Corps of Engineers, U. S. A., etc. Vol. VI, *Botany;* by J. T. ROTHROCK, etc. 1878.—We have been prevented from giving an earlier notice of this fine volume, and want of space now imperatively restricts us to narrow limits. We have not neglected it, however, in the manner that the date on the title page would seem to indicate. The title gives the year 1878, but the volume, passing slowly through the press, was completed and issued in May, 1879, and it should bear that date. The collections reported on were made during the years 1871 and 1875 inclusive, in Nevada, Utah, Colorado, New Mexico and Arizona; also in the southern part of California. But the Californian portion of this report is reduced to a catalogue in an appendix. It furnishes, however, one of the most interesting of the figures, that of the curious Lobeliaceous genus *Palmarella.* As no reference is made to the fact in the letter-press, which is restricted to a mere explanation of the plate, it is due to Professor Rothrock to state that he was, we believe, the original discoverer of the plant, having collected it sometime before Dr. Palmer found it on the borders of Lower California. But the specimens were not communicated to us, nor in any way made known, until after those of Dr. Palmer had been received and described.

This volume contains 414 pages, 4to, and 30 plates, besides a striking frontispiece-plate in color, giving a view of a "grove" (if it may be so called) of the giant Cactus, *Cereus giganteus.* This, again, finds no mention in the Catalogue, but is referred to in the general report. This general report, of fifty pages, is a most interesting and important portion of the volume. From it, if space and time allowed, we should make ample extracts; for it deals with attractive and practical questions in a graphic and taking way. There is first, a sketch of the Colorado District, its character, climate and phytological features, also its agricultural resources and its timber. Then, of New Mexico and the Arizona District, which is scientifically treated in a similar practical way; and a third chapter consists of notes on the economic botany of the region, in which particular attention is paid to the medicinal and supposed medicinal plants.

Chapter IV, or the remainder of the volume, entitled Catalogue of the Plants collected, is the systematic portion of the report; and for this Sereno Watson's Botany of Clarence King's Survey of the 40th parallel is the worthy model. Particular orders are worked up by special collaborators; as, the *Leguminosæ* by Watson, the *Cactaceæ* by Engelmann, who has also contributed other of his favorite orders, *Asclepiadeæ*, *Gentianaceæ*, *Euphorbiaceæ*, *Cupuliferæ*, *Loranthaceæ* and *Coniferæ*; while Professor Porter has done the *Scrophulariacæ*, *Labiatæ*, *Polemoniaceæ*, *Polygonaceæ*, etc.; Dr. Vasey, the Grasses, Professor Eaton, the Ferns, which are conspicuously distinguished by a typography at variance with the rest of the volume; Mr. James, the Mosses; Mr. Austin, the Hepaticæ (a bare list); and Professor Tuckerman, the Lichens.

The plates which illustrate this part of the work, thirty in number, are mostly from Isaac Sprague's drawings, are on the whole well chosen, and are capitally engraved on stone. The most interesting of these may be enumerated. *Canotia holacantha*, admirably represented, heads the list, *Parryella filifolia* is also by Sprague, but *Petalonyx nitidus* is not so. *Leucampyx Newberryi*, *Chætadelpha Wheeleri*, *Nama Rothrockii*, and *Palmarella debilis* are also particularly noteworthy. The latter has been already referred to. Of Cryptogams, there is only *Notholæna Hookeri* of Eaton. While this work was in progress, Dr. Rothrock was called to the chair of Botany in the University of Pennsylvania, at Philadelphia, where he has done much and most acceptable work in building up the department, under conditions in some respects discouraging, but with excellent results. It demands great energy and perseverance to carry on such work and at the same time to bring out a volume like this. A. G.

2. *The Flora of British India.*—Part VI carries the second volume of this standard work from the *Myrtaceæ* (by Duthie) to the *Araliaceæ*, and most of the orders are elaborated by C. B. Clarke. The Himalayan *Osmorrhiza* is named *O. Claytoni* and the species made to include *O. longistylis* and *O. brevistylis;* which in North America are quite distinct. A. G.

3. *Refugium Botanicum.* London, Van Vorst.—This work, so liberally planned by Mr. Wilson Saunders, was left with a hiatus, only the first fascicle of the second volume (devoted to Orchids and edited by Reichenbach, having appeared. There is now a second part, bearing the date of 1878; but each leaf of the letterpress bears the date of October, 1872, and a concluding part is promised. The Orchids illustrated are all tropical. A. G.

4. *Transactions and Proceedings of the Botanical Society of Edinburgh*, vol. xiii, part 2. 1878.—The more interesting articles in this volume are: 1, Professor Balfour's notes of a Continental tour, in 1877, being an account of the celebration of the 400th anniversary of the foundation of the Upsala University, to which he was a delegate, the description and history of the Botanic Garden and other appliances for botanical instruction in that University, followed by a similar account of the gardens and herbaria of Stockholm and Lund; also those of Copenhagen, Kiel, Hamburgh, Berlin, Leyden and Brussels; 2, Sir Robert Christison's capital essay, On the exact measurement of Trees, and its applications; 3, Dr. Bayley Balfour's elaborate and noteworthy paper, On the genus *Halophila*, with 5 plates. A. G.

5. *The Journal of the Linnean Society: Botany*, vol. xvii.—Four parts of this volume have appeared, the latest (no. 101) in May, 1879. The more notable articles are the following.

Experiments on the Nutrition of Drosera rotundifolia, by Francis Darwin. The conclusions reached have become familiar through abstracts published at the time of the experiments. The paper is prefaced by a summary of the various and most diverse opinions of naturalists upon the question whether the leaves of *Drosera* and *Dionæa* can absorb animal matter, and whether, if they do, any advantage to the plant results. The affirmative is clearly made out by well-devised experiment; yet, "it may be pointed out that this advantage of the fed *Drosera* plants is one which would escape the notice of a casual observer." A post-script refers to the full confirmation of his results by the researches of Reess, Kellermann and Raumer, published in the Botanische Zeitung.

Observations on the Genus Pandanus (the Screw-Pines), by Dr. Isaac Bayley Balfour. This paper is prefatory to a full monograph of *Pandaneæ*, which this most promising botanist has undertaken, after a study of several of its representatives in a living state and in their habitats. We may hope that his timely call to the botanical chair at the University of Glasgow will bring increased facilities for this kind of work. Professor Balfour (fil.) has examined at Paris the materials on which Gaudichaud founded thirteen new genera, and he reduces them all to *Pandanus*, along with two genera added by DeVriese.

Notes on the Mahwa Tree (*Bassia latifolia*), by E. Lockwood: A tree of India, largely planted in Bengal, and which "may be called a fountain yielding food, wine and oil, to the inhabitants of the country in which it grows." It is the corolla of this tree which is eaten as food and from which a spirit is distilled. Each tree yields two or three hundred weight of corollas, of which a vast quantity goes to feed the forest birds and beasts, also to supply a nourishing food to the poorer classes; and from a hundred weight of Mahwa six gallons of proof spirit can be produced. The fruit, which follows after the corollas have fallen, yields seeds from which a greenish yellow oil is expressed.

A Synopsis of Hypoxidaceæ, by J. G. Baker. Of *Hypoxys* fifty-one species are characterized: the three related genera give a dozen more.

Observations on Hemileia vastatrix, the so-called Coffee-leaf Disease, by the Rev. R. Abbay. With two plates, containing five illustrations of the coffee-fungus.

Notes on Euphorbiaceæ, by George Bentham. An account of this important paper, especially of the part of it which treats certain points in nomenclature, has already appeared in this Journal.

Notes on Cleistogamic Flowers, chiefly of *Viola*, *Oxalis*, and *Impatiens*, by A. W. Bennett. A clear exposition, illustrated by wood-cut figures. The first is from our North American *Viola cucullata*, in which the cleistogamous blossoms are unusually large and very favorable for observation. Their hollow style with large orifice is delineated, showing that an open tube extends to the cavity of the ovary. But Mr. Bennett has not been able to detect the entrance of a single pollen-tube into the ovary through this open passage, and indeed he suspects that they penetrate the tissue of the style. Observations should be made here upon the native plant; and we commend the investigation to some of our botanists who may like to try their hand at microscopic investigation. They will find it interesting to observe that wonderful phenomena, the growth and prolongation of the pollen-tubes from the anther to the stigma through a considerable distance in a straight line, with unerring certainty, as if guided by some unseen agency in the right direction.

On the Absorption of Rain and Dew by the green parts of Plants; by the Rev. George Henslow. Along with Boussingault's contemporary researches, these experiments appear to settle the question against the conclusions of Duchartre, who confidently decided that foliage could not absorb water or aqueous vapor. The gardeners could never believe this, and it is now clear that leaves and other green parts may imbibe moisture and do so evidently under favorable circumstances.

Note on the Genus Oudneya Brown, by Dr. Henry Trimen. The accidental discovery of Dr. Oudney's herbarium, which Brown had tucked away, has brought to light the plant upon which Robert Brown founded this genus. It proves to be the *Henophyton deserti*, as the authors of the Genera Plantarum had indeed surmised, though they had sought in vain for the original. A nice question in nomenclature now arises. Brown unqualifiedly calls his plant the *Hesperis nitens* of Viviani. Cosson and Durieu, trusting to this, and ascertaining that the plant in their hands is not Viviani's *Hesperis*, confidently concluded that it could not be Oudneya, and so established, upon its true characters, the genus *Henonia* or *Henophyton*. Hooker and Bentham adopt the genus, guessing that it may be Brown's *Oudneya*, a conclusion to which Brown's character would never lead them. For the latter, not having mature seed, makes of it an Arabideous genus, instead of a Brassicaceous. Shall the rightly characterized genus now be superseded by the imperfectly and by implication erroneously described genus, which was also confused with something else? Dr. Trimen implicitly assumes that it should. If Brown had been a botanist of less fame and less accuracy, the current name (*Henophyton*) would probably remain undisturbed. The question may be settled by enquiring what course the authors of the Genera Plantarum would have pursued if they had identified Brown's genus by finding his specimen. We suppose they would have adopted the older name of *Oudneya;* and if so, it may claim to be adopted now. A. G.

6. *Floral Dissections illustrative of the typical Genera of the British Natural Orders, Lithographed by the* Rev. George Henslow, Lecturer on Botany at St. Bartholomew's Hospital, &c.

For the use of Schools and Students in Botany. London: E. Stanford.—An oblong 4to, with 20 pages of letter-press and 8 plates crowded with well-chosen analyses, of rather small size, between one and two hundred on each plate. The price is not mentioned, and is probably low; the execution of the figures is fairly good, and the letter-press explaining them is also a model of condensation. The book may be recommended to students and classes in the United States. A. G.

7. *Decease of Botanists.*—The mortality among botanists during the first half of the year 1879 is remarkable. Among the deceased are the venerable *Reichenbach*, *Itzigsohn*, *Angström*, *Bueck* (who made the Candollean index), *Wm. Schimper* (the schoolmate of Agassiz and one of the first investigators of phyllotaxy, but who passed most of his life in Abysinia), *Grisebach*, *Karl Koch*, *Moore* of Glasnevin, besides our own *Bigelow* and *Robbins*. A. G.

8. PSYCHE: *Anatomy of* Amblychila cylindriformis *Say*, by C. F. GISSLER. This carefully prepared memoir is published in volume II of Psyche, the number for May–June, 1879. It is illustrated by one plate, well executed on stone by the author.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Preliminary Note on the Substances which produce the Chromospheric Lines;* by J. NORMAN LOCKYER, F.R.S.—Hitherto, when observations have been made of the lines visible in the sun's chromosphere, by means of the method introduced by Janssen and myself in 1868, the idea has been that we witness in solar storms the ejection of vapors of metallic elements with which we are familiar from the photosphere.

A preliminary discussion of the vast store of observations recorded by the Italian astronomers (chief among them Professor Tacchini), Professor Young and myself, has shown me that this view is in all probability unsound. The lines observed are in almost all cases what I have elsewhere termed and described as *basic lines;* of these I only need for the present refer to the following:—

b_1 ascribed by Ångström and Kirchoff to iron and nickel.
b_4 " Ångström to magnesium and iron.
5268 by Ångström to cobalt and iron.
5269 " " calcium and iron.
5235 " " cobalt and iron.
5017 " " nickel.
4215 " " calcium, but to strontium by myself.
5416 an unnamed line.

Hence, following out the reasoning employed in my previous paper, the bright lines in the solar chromosphere are chiefly lines due to the not yet isolated bases of the so-called elements, and the solar phenomena in their totality are in all probability due to dissociation at the photospheric level, and association at higher levels. In this way the vertical currents in the solar atmosphere, both ascending and descending, intense absorption in sun-spots, their association with the faculæ, and the apparently continuous spectrum of the corona and its structure, find an easy solution.

We are yet as far as ever from a demonstration of the cause of the variation in the temperature of the sun; but the excess of so-called calcium with minimum sun-spots, and excess of so-called hydrogen with maximum sun-spots follow naturally from the hypothesis, and afford indications that the temperature of the hottest region in the sun closely approximates to that of the reversing layer in stars of the type of Sirius and α Lyræ.

If it be conceded that the existence of these lines in the chromosphere indicates the existence of basic molecules in the sun, it follows that as these lines are also seen generally in the spectra of two different metals in the electric arc, we must be dealing with the bases in the arc also.

2. *An Arabic Scientific Journal.*—The first number of a Scientific Monthly Journal in Arabic, has been recently issued at Beirût, in Syria. It is published by Sh. Makarius & Company of that city.

3. *Bulletino del Vulcanismo Italiano;* Professor M. S. DI ROSSI. Roma, 1878.—A few years ago Cav. Michele Rossi determined to attempt the collection and monthly publication of facts connected with Italian Vulcanology. The experiment succeeded, and a volume of 140 pages has been issued recording all the phenomena of internal telluric dynamics observed in Italy and Sicily during 1878. A list is given of twenty-six Italian observatories where seismic observations are recorded, and whose observers are in communication with Professor di Rossi. Among minor notices we find mention of various new seismological observatories, including that of the Solfatara at Pazzuoli, and of the earthquake which was felt at Fiulmalbo, Florence, and Rocca di Papa. There are letters on the application of the microphone to seismological studies, from Professor di Rossi and Count G. Mocenigo; and the Umbrian earthquake of September, 1878, is described by Professor A. Ricci. Silvestri gives an account of the mud eruption which broke out on the sides of Etna near Paterno in December; and Palmieri continues his "Cronaca Vesuviana" to the end of September, 1878. An exact account of the time of occurrence of earthquake phenomena in any part of Italy is entered in a tabular form, and it is surprising to notice that not a day passes in Italy without some indication of endogenous dynamic action. At the end of the volume is a large diagram showing at a glance the daily distribution of earthquakes throughout Italy.

But the most interesting article in the Bulletino is that on the *application of the microphone to the study of subterraneous meteorology*, by Professor Michele di Rossi. In 1875 Count Mocenigo, of Vicenza, made an observation which was nothing less than the fundamental fact of the microphone. He observed that electric currents indicate in a galvanometer perturbations and interruptions by means of frictions and shocks produced artificially between conductors not in perfect contact. He also observed that the same phenomena were produced by natural and unknown causes, when the apparatus had not received any artificial shock. From the account of his observations Professor di Rossi concludes that these unknown perturbations arose from microseismic oscillations of the soil. He communicated his views to Count Mocenigo, who at once commenced experimenting in the direction indicated, when the news of the invention of the microphone in America was received. Professor di Rossi then commenced a series of experiments with the microphone in the Seismic Observatory which he has established at Rocca di Papa, seventeen miles from Rome. A special microphone, consisting of a balanced pointed lever lightly touching a plate of silver, was mounted on a stone pedestal and was placed twenty meters under ground, at a distance from habitations and from roads. It was also thoroughly isolated, and shut up in a box filled with wool. The instrument was watched during some of the stillest hours of the night, and the same mysterious sounds which Count Mocenigo had recognized were heard by di Rossi, which he considers were incontestably natural and intratelluric. The microseismic sounds were speedily differentiated from other sounds, and their nature was completely confirmed by their frequent coincidence with motions of the seismograph. On one occasion, as di Rossi was listening at about half past three o'clock in the morning, the telephone connected with his subterranean microphone emitted sounds like the discharge of musketry, of such loudness that he feared they would awaken a child who slept in the same room, and he therefore disconnected the telephone. A short time afterward, toward four o'clock, a sensible shock of earthquake occurred, for which the sounds had been the microphonic preparation. The microphone was afterward transported to the observatory on Vesuvius, and it was then possible to trace the precise correspondence between the movements of the seismograph and the sounds of the microphone. The above is condensed from G. F. Rodwell, Nature, vol. xx, p. 179.

In this connection it may be remarked that the sources of the seismic vibrations which become audible through the microphone may be various. Thus, they might be produced by:

(1.) The explosion of bubbles made by the escaping vapors, which in the case of viscid lavas would require considerable internal pressure before rupture.

(2.) The sudden production or condensation of vapors.

(3.) The more general condition of stress produced in the earth's crust, resulting in more or less yielding along lines of least resistance.

The premonitory sounds heard in the microphone may with probability be referred to the first or second class. C. G. R.

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ART. XXVI.—*The Pertinacity and Predominance of Weeds;* by ASA GRAY.

A WEED is defined by the dictionaries to be "Any useless or troublesome plant." "Every plant which grows in a field other than that of which the seed has been [intentionally] sown by the husbandman is a weed," says the Penny Cyclopædia, as cited in Worcester's Dictionary. The Treasury of Botany defines it as "Any plant which obtrusively occupies cultivated or dressed ground, to the exclusion or injury of some particular crop intended to be grown. Thus, even the most useful plants may become weeds if they appear out of their proper place. The term is sometimes applied to any insignificant-looking or unprofitable plants which grow profusely in a state of nature; also to any noxious or useless plant." We may for present purposes consider weeds to be plants which tend to take prevalent possession of soil used for man's purposes, irrespective of his will; and, in accordance with usage, we may restrict the term to herbs. This excludes predominant indigenous plants occupying ground in a state of nature. Such become weeds when they conspicuously intrude into cultivated fields, meadows, pastures, or the ground around dwellings. Many are unattractive, but not a few are ornamental; many are injurious, but some are truly useful. White Clover is an instance of the latter. Bur Clover (*Medicago denticulata*) is in California very valuable as food for cattle and sheep, and very injurious by the damage which the burs cause to wool. In the United States, and perhaps in most parts of the world, a large majority of the weeds are introduced plants, brought into the country directly or indirectly by man. Some—such as Dandelion, Yarrow, and probably the common Plantain and the common Purslane—are importations as weeds, although the species naturally occupy some part of the country.

Why weeds are so pertinacious and aggressive, is too large and loose a question: for any herb whatever when successfully aggressive becomes a weed; and the reasons of predominance may be almost as diverse as the weeds themselves. But we may enquire, whether weeds have any common characteristic which may give them advantage, and why the greater part of the weeds of the United States, and probably of similar temperate countries, should be foreigners.

As to the second question, this is strikingly the case throughout the Atlantic side of temperate North America, in which the weeds have mainly come from Europe; but it is not so, or hardly so, west of the Mississippi in the region of prairies and plains. So that the answer we are accustomed to give must be to a great extent the true one, namely, that, as the district here in which weeds from the Old World prevail was naturally forest-clad, there were few of its native herbs which, if they could bear the exposure at all, were capable of competition on cleared land with emigrants from the Old World. It may be said that these same European weeds, here prepotent, had survived and adapted themselves to the change from forest to cleared land in Europe, and therefore our forest-bred herbs might have done the same thing here. But in the first place the change must have been far more sudden here than in Europe; and in the next place, we suppose that most of the herbs in question never were indigenous to the originally forest-covered regions of the Old World; but rather, as western and northern Europe became agricultural and pastoral, these plants came with the husbandmen and the flocks, or followed them, from the woodless or sparsely wooded regions farther east where they originated. This, however, will not hold for some of them, such as Dandelion, Yarrow, and Ox-eye Daisy. It may be said that our weeds might have come to a considerable extent from the bordering more open districts on the west and south. But there was little opportunity until recently, as the settlement of the country began on the eastern border; yet a certain number of our weeds appear to have been thus derived: for instance, *Mollugo verticillata*, *Erigeron Canadense*, *Xanthium*, *Ambrosia artemisiæfolia*, *Verbena hastata*, *V. urticifolia*, etc., *Veronica peregrina*, *Solanum Carolinense*, various species of *Amarantus* and *Euphorbia*, *Panicum capillare*, etc. Of late, and in consequence of increased communication with the Mississippi region and beyond—especially by rail-roads—other plants are coming in to the Eastern States as weeds, step by step, by somewhat rapid strides; such as *Dysodia chrysanthemoides*, *Matricaria discoidea*, *Artemisia biennis*. Fifty years ago *Rudbeckia hirta*, which flourished from the Alleghanies westward, was unknown farther east. Now, since twenty years, it is an abundant and conspicuous weed in grass-fields throughout the Eastern States, having been accidentally disseminated with Red-clover seed from the Western States.

There are also native American weeds, doubtless indigenous to the region, such as *Asclepias Cornuti*, *Antennaria margaritacea* and *A. plantaginifolia*, and in enriched soils *Phytolacca decandra*, which have apparently become strongly aggressive under changed conditions. These are some of the instances which may show that predominance is not in consequence of change of country and introduction to new soil.

In many cases it is easy to explain why a plant, once introduced, should take a strong and persistent hold and spread rapidly. In others we discern nothing in the plant itself which should give it advantage. *Lespedeza striata* is a small and insignificant annual, with no obvious provision for dissemination. It is a native of China and Japan. In some unexplained way it reached Alabama and Georgia and was first noticed about thirty-five years ago; it has spread rapidly since, especially over old fields and along road-sides, and it is now very abundant up to Virginia and Tennessee, throughout the middle and upper districts, reaching even to the summits of the mountains of moderate elevation. In the absence of better food it is greedily eaten by cattle and sheep. The voiding by them of undigested seeds must be the means of dissemination; but one cannot well understand why it should spread so widely and rapidly, and take such complete possession of the ground. It is one of the few weeds which are accounted a blessing.

Professor Claypole, of Antioch College, Ohio, has recently contributed to the Third Report of the Montreal Horticultural Society (1877–8), an interesting Essay, On the Migration of Plants from Europe to America, with an Attempt to explain Certain Phenomena connected therewith. The phenomena which he would explain are the abundant migration of numerous weeds from Europe to the shore of North America, while others fail to come, and the general failure of North American weeds to invade Europe. We have offered a fairly good explanation of the first. And Professor Claypole goes far toward explaining the second when he notes that seed is (or formerly was) mainly brought from the Old World to the New, and the same may be said of cattle and other emigration; that the cooler and shorter summer of the north of Europe renders the ripening of some seed precarious, etc. He does not mention the fact that American plants by chance reaching

Europe have to compete with a vegetable world in comparatively stable equilibrium of its species, while European weeds coming —or which formerly came—to the United States found the course of nature disturbed by man and new-made fields for which they could compete with advantage. But his ingenious hypothesis is that weeds have a peculiarly "plastic nature, one capable of being moulded by and to the new surroundings," by which the plant "ere long adapts itself, if the change is not too great or sudden, to its new situation, takes out a new lease of life, and continues in the strictest sense a weed;" "that the plants of the European flora possess more of this plasticity, are less unyielding in their constitution, can adapt themselves more readily to new surroundings," and that it is "the lack of this plasticity in the American flora which incapacitates it from securing a foot-hold and obtaining a living in the different conditions of the New World;" that although "in the Miocene era the European and American floras were very much alike," yet "since that era the European flora has been vastly altered, while the American flora still retains a Miocene aspect, and is therefore the elder of the two;" "that this long persistence of type in the American flora may have induced, by habit, a rigidity or indisposition to change;" that "the European is thus better able to adapt itself to the strange climate and conditions—that is, to emigrate—than the American:" and thus, being more plastic or adaptable it succeeds in the New World, while the less adaptable American flora fails in the Old World."

So far as we know, the greater plasticity of European as compared with American plants is purely hypothetical. "More plastic" would mean of greater variability, which, if true, might be determined by observation. Because Europe once had more species or types in common with North America than it now has, it does not seem to follow that the former has "a younger plant-life," or that its existing plants are more recent than those of the American flora. And as already intimated, so refined an hypothesis is hardly necessary for the probable explanation of the predominance of Old World weeds in the Atlantic United States.

Mr. Henslow, in his remarkable memoir, On the Self-Fertilization of Plants (which we reviewed in the June number of this Journal) derives from different but equally theoretical premises an opposite conclusion,—namely, that weeds or intrusive and dominant plants in general, and of great emigrating capabilities, have "a longer ancestral life-history than their less aggressive relatives." He also maintains that weeds, and plants best fitted for domination in the manner of weeds, possess a common characteristic to which this dominance may be attributed, namely, that they are in general self-fertilized plants. A rapid generalizer might find confirmation of this in the converse, which is obviously true, that plants with blossoms very specially adapted for cross-fertilization by particular insects, and therefore dependent on such special aid, are comparatively local and unaggressive; yet some of these are widely distributed. It will also be understood that self-fertilization may give advantage to an intruding plant at the outset, by enabling an exceptionally well-fitted individual to initiate a favored race. And self-fertilization, with its sureness, would always be most advantageous unless cross-fertilization brings some compensatory advantage greater on the whole than that of immediate sureness to fertilize.

But the test of the theory is, whether weeds and emigrating herbs in general are more self-fertilizing or less subject to cross-fertilization than the majority of related plants, and whether many or any of them are actually self-fertilized through a succession of generations. It seemed to us that, in a limited way, the weeds which Europe has given to North America might answer this question. To keep within bounds and to have a case with all the data unquestionable, we will collate the weeds of European parentage which evince a dominating character in the United States east of the Mississippi, referring for the purpose to the Manual of the Botany of the Northern United States and Chapman's Southern States Flora. The latter, however, adds not a single weed from Europe of any predominance. We include only those which have taken a strong hold and become prominent either by their general diffusion over the area or by taking marked possession of certain districts. For examples of the latter take *Echium vulgare* in Virginia, *Ranunculus bulbosus* and *Leontodon autumnale* in Eastern New England, and *Genista tinctoria* which covers certain tracts in the eastern part of Massachusetts, although nearly unknown elsewhere. We must include several species which as weeds came from Europe, although they are probably, some of them undoubtedly, indigenous to some part of the United States.

The following are the herbaceous plants naturalized from Europe and of an aggressive character in the Atlantic United States. Herbs of recent introduction, and those of however ancient naturalization which have not either spread widely or increased greatly over a considerable district, are omitted.

The 18 species in italic type, nearly half of them grasses, are probably indigenous to some portions of North America. In some cases the introduced and the indigenous plants have come into contact.

Ranunculus bulbosus.
Ranunculus acris.
Nasturtium officinale.
Sisymbrium officinale.
Brassica Sinipistrum.
Raphanus Raphanistrum.
Capsella Bursa-pastoris.
Reseda Luteola.
Saponaria officinalis.
Silene inflata.
Lychnis Githago.
Stellaria media.
Portulaca oleracea.
Malva rotundifolia.
Genista tinctoria.
Trifolium arvense.
Trifolium agrarium.
Trifolium repens.
Daucus Carota.
Pastinaca sativa.
Conium maculatum.
Tussilago Farfara.
Inula Helenium.
Gnaphalium uliginosum.
Anthemis Cotula.
Achillæa Millefolium.
Tanacetum vulgare.
Leucanthemum vulgare.
Cirsium arvense.
Cirsium lanceolatum.
Lappa officinalis.
Cichorium Intybus.
Leontodon autumnale.
Taraxacum Dens-leonis.
Plantago major.
Plantago lanceolata.
Anagallis arvensis.
Verbascum Thapsus.
Verbascum Blattaria.
Linaria vulgaris.
Mentha viridis.
Mentha piperita.
Calamintha Nepeta.
Calamintha Clinopodium.
Nepeta Cataria.
Nepeta Glechoma.
Marrubium vulgare.
Galeopsis Tetrahit.
Leonurus Cardiaca.
Lamium amplexicaule.
Echium vulgare.
Symphytum officinale.
Echinospermum Lappula.
Cynoglossum officinale.
Solanum nigrum.
Chenopodium album.
Chenopodium hybridum.
Chenopodium Botrys.
Polygonum aviculare.
Polygonum Convolvulus.
Rumex crispus.
Rumex sanguineus.
Rumex Acetosella.
Allium vineale.
Alopecurus pratensis.
Phleum pratense.
Agrostis vulgaris.
Agrostis alba.
Dactylis glomerata.
Poa annua.
Poa compressa.
Poa pratensis.
Poa trivialis.
Eragrostis poæoides.
Festuca ovina.
Festuca pratensis.
Bromus secalinus.
Lolium perenne.
Triticum repens.
Triticum caninum.
Anthoxanthum odoratum.
Panicum glabrum.
Panicum sanguinale.
Panicum Crus-galli.
Setaria glauca.
Setaria viridis.

The plants of this list, regarded as weeds, are of very various character; and several of them, such as White Clover and most of the grasses, where most dominant, do not fall under the ordinary definition of weeds at all, but under that of plants useful to the farmer. Some, like Purslane, are only garden-weeds; some belong to pastures and meadows; others affect road-sides. The fewness of European corn-weeds is remarkable. Chess and Corn-cockle (*Lychnis Githago*) are the only ones on the list. Corn Poppy, Blue-bottle and Knapweed (*Centaurea Cyanus* and *C. nigra*) and Larkspur are conspicuously wanting; but the last two are not wholly unknown in some parts of the country.

But the only question before us is, whether these plants introduced from Europe are or are not self-fertilized, or more habitually so than others, so that this may be accounted an element of their predominance. Apparently this question must be answered in the negative. The question is not whether they are self-fertilizable. The great majority of plants are so, even of those specially adapted for intercrossing. The plants of this list appear to belong to the *juste milieu.* Only one (*Rumex Acetosella*) is completely diœcious; a few are incompletely diœcious or polygamous; the two species of *Plantago* are dichogamous to the extent of necessary dioicism or monoicism; a large number of the corolline species are either proterandrous or proterogynous, including two or three anemophilous species, and all the Grasses (which form the last quarter of the list) are anemophilous and more or less dichogamous, and therefore not rarely cross-fertilized. Of those which are not anemophilous we notice none which are not habitually visited by insects (except perhaps *Gnaphalium uliginosum*), and which therefore are almost as likely to be cross-fertilized as close-fertilized; while in not a few (such as the *Compositæ* generally and most of the other *Gamopetalæ*) the arrangements which favor inter-crossing are explicit. There is no cleistogamous and therefore necessarily self-fertilized plant in the list, except *Lamium amplexicaule*, which also cross-fertilizes freely.

In California the prevalent weeds are largely different from those of the Atlantic States and, as would be expected, are mostly of indigenous species or immigrants from South America; yet the common weeds of the Old World, especially of Southern Europe, are coming in. The well-established and aggressive ones, such as *Brassica nigra*, *Silene Gallica*, *Erodium cicutarium*, *Malva borealis*, *Medicago denticulata*, *Marrubium vulgare* and *Avena sterilis*, were perhaps introduced by way of Western South America. They are mostly plants capable of self-fertilization, but also with adaptations (of dichogamy and otherwise) which must secure occasional crossing.

We cannot avoid the conclusion that self-fertilization is neither the cause, nor *a* perceptible cause of the prepotency of the European plants which are weeds in North America.

A cursory examination brings us to a similar conclusion as respects the indigenous weeds of the Atlantic States, those herbs which under new conditions, have propagated most abundantly and rapidly, and competed most successfully in the strife for the possession of fields that have taken the place of forest. The most aggressive of these in the Northern States are *Epilobium spicatum* in the newest clearings, which is dichogamous (proterandrous) to a degree which practically forbids self-fertilization; and in older fields, *Asclepias Cornuti*, which is specially adapted for cross-fertilization by flying insects; *Antennaria plantaginifolia* and *A. margaritacea*, which are diœcious; and next to these perhaps the two wild Strawberries, then *Erigeron annuum* and *E. strigosum*, with certain Asters and Golden-rods, all insect-visited and dichogamous, and *Verbena hastata*, *urticifolia*, etc., the frequent natural hybridization of which testifies to habitual intercrossing.

Those who suppose that only conspicuous or odorous flowers are visited by flying insects should see how bees throng the small, greenish, and to us odorless blossoms of *Ampelopsis* or Virginia Creeper and of its Japanese relative.

ART. XXVII.—*On a possible cause of variation in the proportion of Oxygen in the Air*; by EDW. W. MORLEY, M.D., PH.D., Professor of Chemistry in Western Reserve College, Hudson, Ohio.

PROFESSOR LOOMIS has proposed the theory that certain great and sudden depressions of temperature at the surface of the earth are caused, not by the transfer of cold air from higher to lower latitudes, but by the vertical descent of air from cold elevated parts of the atmosphere. The evidence supporting this theory was published in this Journal in January and July, 1875. It occurred to the writer some time since that if this theory were true, as the evidence makes very probable, the air at the surface of the earth during such a great and sudden depression of temperature might well contain a smaller proportion of oxygen than the average. Dalton, reasoning from the fact that oxygen has a greater specific gravity than nitrogen, argued that the proportion of oxygen to nitrogen in the atmosphere should decrease with increasing altitude above the earth's surface; whether he clearly enough recognized that such a regular decrease would be realized only in an atmosphere in a state of equilibrium undisturbed by convection currents, the writer does not know, not having seen Dalton's memoir. Such a decrease of atmospheric oxygen with increasing altitude has not yet been detected by analysis, although the amount of decrease, on the theory that oxygen and nitrogen are distributed in the atmosphere according to the law which would prevail in case of equilibrium, is so rapid that it would be detected with ease, even in altitudes attained in every holiday ascent of a balloon. This decrease may be calculated from the formula $R = R_0 0{\cdot}9832960^{H}$, where H denotes the height above the earth's surface expressed in kilometers, R_0 denotes the ratio of the tension of oxygen to that of nitrogen at the surface of the earth, and R denotes the same ratio for the height H. The constant is computed from the determinations by Regnault of the weights of a litre of oxygen and of nitrogen, and of the specific gravity of mercury. The following table gives in the second column the ratio of the tension of oxygen to that of nitrogen at the height in kilometers given in the first column, and the per cent of oxygen at the same height in the third column. The per centage of oxygen at the earth's surface assumed in the table is that used in the tables for gas analysis in Bunsen's Gasometrische Methoden.

It will be seen that the composition here calculated for a height of a single kilometer is so different from that at the surface that analysis of no very refined accuracy would detect the variation with ease. But no such variation has been detected even in samples of air collected at the greatest elevations attainable.

Height, Kilometers.	Ratio of O to N.	Per cent of O.	Height, Kilometers.	Ratio of O to N.	Per cent of O.
0	26·52 %	20·96 %	10	22·41 %	18·31 %
1	26·08	20·68	20	18·93	15·92
2	25·64	20·41	30	16·00	13·79
3	25·21	20·14	40	13·52	11·91
4	24·79	19·87	50	11·42	10·25
5	24·38	19·60	60	9·65	8·80
6	23·97	19·34	70	8·16	7·54
7	23·57	19·07	80	6·89	6·45
8	23·18	18·82	90	5·82	5·50
9	22·79	18·56	100	4·92	4·69

But although this is the case, it is certain that in the atmosphere of the same place at different times the oxygen varies by more than one-fortieth of its average amount. Variations so large as this are rare, but variations of the one-hundredth or two-hundredth part are common. It therefore seemed to the writer proper to examine whether facts bear out the conjecture that certain great and sudden local depressions of temperature are caused by the descent of cold air from the upper part of the atmosphere, and that such air may by its poverty in oxygen throw some light on a question in meteorology and a question concerning the physics of a mixture of different gases.

In the number of Wiedemann's Annalen for April of the current year, Jolly has published the results of numerous and very accurate analyses of atmospheric air. He asserts a connection between the variations in composition detected and the direction of the winds when the sample was collected. He considers himself justified in concluding that the atmosphere of tropical regions is poorer in oxygen than that of polar regions, and supposes that at the equator more oxygen is consumed in processes of oxidation than is set free by those of reduction, while the opposite is true near the poles. Since no difference in the composition of the atmosphere at the equator and at the poles has been detected, while on this theory the difference must be one large enough to account for the extreme variations found in temperate regions, and to account for them after such abnormal air had been exposed to admixture with air of a different composition during a passage of thousands of miles, the writer fears that the theory of Jolly will need further proof. Other reasons for a similar doubt will suggest themselves.

On the writer's theory, a sample of air collected at the center of an area covered by a descending current of cold air would at some given instant be a sample fresh from the upper part of the atmosphere, but little exposed to admixture on the way. If before its descent it had remained at a great height for a long time, it might well have lost some of the oxygen which it contained when it was at some previous time at the level of the sea, and the difference might be enough to be detected. An observer at one side of this central point would have samples more or less mingled with surface air; but even then, a deficiency of oxygen might be detected by accurate analysis.

The writer hopes to make arrangements for the regular collection of samples at points which Professor Loomis has indicated as regions of frequent descent of cold air from great heights. But while laying plans for the work, he has thought best to ascertain whether some light on the changes in the constitution of the atmosphere might be obtained by analyzing samples of air collected at home. Having an apparatus for gas analysis lately constructed for the study of the gas issuing from the numerous gas wells of his vicinity, he used this for such determinations. In general, the apparatus is constructed on the plan of McLeod's modification of Frankland and Ward's apparatus. But some important modifications have been introduced, and excellent workmanship was bestowed on details. Some such points but slightly concern analyses by explosion. The connection between the eudiometer and absorption tubes is novel, and has worked well. This will be described in some proper connection. Here will be described everything necessary for a judgment of the accuracy of the analyses to be cited.

The eudiometer and pressure tubes were made from the writer's drawings by Geissler, whose recent death is a loss to science, and a personal loss to so many who have been aided by him. The stop-stocks at the top of these tubes will retain a Torricellian vacuum for weeks. The internal diameters of the tubes are 20·9 and 10·7 millimeters. At the lower end of the eudiometer tube is a glass stop-cock, the use of which is simply to permit the ready cleaning of the tube. Its glass plug is withdrawn, and in place of it is put one of vulcanite so bored that acids or water can be aspirated through the eudiometer without dismounting it and without drawing off the mercury from the pressure tube. The stop-cock at the top of the eudiometer tube is also provided with a similar plug for the same purpose. The pressure and eudiometer tubes are surrounded by a stream of water entering at the top of the pressure tube and running away from near the bottom of the two. The level of water is kept constant by a device similar to that of Thomas, described in a late number of the Journal of the Chemical Society, but perhaps superior to his in some respects. The flow of mercury to and from the movable reservoir is controlled by an iron stop-cock which is attached to the iron tripod support of the whole apparatus. The plug of this stop-cock is vertical, and is prolonged by a shaft which puts it within easy reach of the observer. By means of a long handle on this shaft, the stop-cock can be moved with the greatest delicacy. From this stop-cock, an iron tube, cast in the same piece, extends under the ends of the glass tubes of the apparatus, and two small iron tubes rise from this horizontal tube; these last meet the glass tubes and are connected with them by short tubes of patent black rubber containing no free sulphur. The connectors are tied so as to endure the pressure of mercury having a head of several feet, and are surrounded with mercury so as to be absolutely air-tight. The plug of the iron stop-cock is also so surrounded with mercury that the entrance of air is absolutely impossible, and the same precaution was taken at the junction of the two small iron tubes with the horizontal tube. The cast iron of this tube and stop-cock is well japanned, and no leakage through its pores has occurred.

The measurement of the volume of gas in such an apparatus demands an accurate adjustment of the level of the mercury in the eudiometer tube to one of the marks of the graduations. Such an adjustment can be accurately made by admitting mercury very slowly from the reservoir, and closing the stop-cock at the required moment. But if now the temperature of the gas be not quite constant, the adjustment can be renewed for a second reading only by letting in or out a column of mercury of several millimeters, again permitting it very slowly to approach the proper level, and stopping at the instant of contact. It is quite impossible to open the stop-cock, admit the twentieth or fortieth of a millimeter of mercury, note the right instant, and then again close the stop-cock. But for accurate work, the means of altering the level of the mercury by such small quantities, and of doing it by a continuous movement, seemed important. In the end, therefore, of the horizontal iron tube, there works a plunger, packed with great care, which can be moved in or out by a screw. By means of this micrometric movement, the level of the mercury which has been adjusted by the stop-cock can be altered with the greatest delicacy, and readjusted till perfect steadiness is attained. Danger of leakage through the washers around the plunger was prevented by providing a seat into which, when the plunger is screwed quite home, it fits so as to cut off connection between the pressure tube and the rest of the apparatus. The mercury in the pressure tube is, by the use of this valve, always kept at such a height that any possible leakage is that of mercury outward, and not of air inward.

The eudiometer and pressure tubes are cemented into the brass cap of the glass cylinder containing the water intended to keep all parts of the apparatus at the same temperature. The level of the two graduations with respect to each other is therefore constant.

When the writer planned to make analyses of air in order to detect if possible some law in its variations of composition, he expected to have to do with quantities but little larger than the errors of observations. Some thought was therefore given to the methods of keeping such errors as small as possible. It was hoped that if the probable error of a determination of oxygen with this apparatus was not larger than the probable error of the analyses made by Bunsen in January and February, 1846, the object of the analyses would be attained. Such analyses as those of Bunsen would abundantly serve to establish variations of the four hundredth part of the average amount of oxygen contained in the atmosphere. The writer expected to have commonly to do with such variations, and therefore computed the comparative accuracy of analyses of air made with the long eudiometer of Bunsen's experiments, and with the apparatus used in the present work. In the first analysis by Bunsen of the air of January ninth, the length of the column of gas in the eudiometer was in round numbers, 840 millimeters, and its tension 510. The tension was determined by four readings, and the apparent volume of air taken by one reading. An error in the last reading would produce also an error of the same sign in the observed tension, so that these two errors are not independent. Their influence on the result is therefore computed by simply adding them; the other errors are independent of this joint error and of each other. And the influence of the four independent errors on the result is computed by taking the square root of the sum of their squares. If we repeat this computation for the different volumes and tensions of the second and third measurements, referring all the probable errors to the volume of air first taken, and obtain the probable errors of the three measurements, we may obtain the probable error of the final result by adding the square of the first probable error to the squares of the third parts of the second and third, and taking the square root of the sum.

The probable error of a single reading of the level of the mercury in Bunsen's experiments is not given; but we may compare the two methods by assuming arbitrarily some probable error, provided that we assume the same error in both computations. The first column of the following table gives the influence of a probable error of one-tenth of a millimeter in a single reading in each of the three measurements of the analysis quoted from Bunsen.

In the measurement of a volume of gas with the Frankland and Ward or McLeod apparatus, the mercury is brought to that mark in the eudiometer tube which will give a suitable tension, and the height in the pressure tube at which the mercury stands is determined. An error in determining the volume of gas in the eudiometer tube involves an error of the same sign in the observed tension. If we add these two dependent errors we have one of the two independent errors affecting this mode of measurement, the other being the error probably made in determining the upper level of the mercury in the pressure tube. Adding the squares of these two and taking the square root, we have the probable error of a measurement with the apparatus. If we treat the second and third measurement in the same way, and compute the effect of these three probable errors on the final result, we get the numbers in the second column of the following table.

Probable errors of measurements of gas, and of final results, occasioned by a probable error of the tenth of a millimeter in each reading.

	In Analysis cited from Bunsen.	With Frankland and Ward apparatus.
In measurement of air taken	0·046 %	0·034 %
In measurement of air and hydrogen	0·050	0·042
In measurement after explosion	0·039	0·031
Probable error of result	0·051	0·038

It is obvious that with the same error probable in each reading, the use of the rapidly working apparatus involves no sacrifice of accuracy to convenience, as far as the conditions of *observation* are concerned.

To obtain the degree of accuracy needed for the present purpose, it is necessary to take account of the expansion of the mercury in the column which measures the pressure, and also of the linear expansion of the scale which measures the tension, and of the cubical expansion of the eudiometer tube. Since all these are at the same temperature with the gas to be measured, it is easy to prepare a table giving the correction not only for the expansion of the gas but also for the expansion of mercury, scale and eudiometer. Such a table, giving on a single page, for every tenth of a centigrade degree from zero to thirty degrees, the logarithmic factor to be added to the logarithms of the observed volume and observed tension, makes the work of reduction very slight. Most tables of correction of the volumes of gas contain a logarithm to be subtracted; for convenience it should be additive; and five places of decimals should not be exceeded. Unless measurements can be made ten times more accurate than Bunsen's, five places of logarithms distinguish smaller differences than observation deals with; five places permit instant interpolation for hundredths of a degree, and a greater number waste time and possess no advantage whatever.

The eudiometer was calibrated by filling it with air-free water, and weighing the quantity expelled as the mercury rose to each successive mark of the graduation. This was done four times for each division; the probable error of a single determination was found to be 8·6 milligrams of water. The results were all reduced to the temperature of melting ice. There were seventeen divisions in the eudiometer tube, now broken, which was used in all the analyses in this paper. The volume of gas to be measured was always brought to one of the two divisions which permitted measurement under the most favorable conditions, and its tension determined; it was then brought to the other division, and its tension again determined. Two independent measurements thus obtained eliminated the chance of error in identifying divisions on the scale, and also afforded the means of ascertaining the probable error of a measurement. In the analyses contained in this paper, the quantity of air taken was unfortunately limited by the circumstance that the collecting tubes at hand were small; the probable error of the results so far obtained is therefore much greater than is due to the care used in observing. In analyses made after the present month this mistake of judgment will be corrected. The mean quantity of air taken in an analysis so far has been 38·9 cubic centimeters measured at zero and 760 millimeters. From 196 pairs of measurements it has been computed that the probable error of a single determination of volume is its 5800th part. Hence the probable error of a determination of oxygen in the air is the 7200th part, and the probable difference of two determinations on the same sample is the 5100th part. A second analysis was always made when the first showed a deficiency of oxygen. A comparison of the results will show whether the accuracy indicated by computation was obtained.* The writer has in hand an entirely new construction of the pressure tube, and some modifications of the optical appliances for reading the level of the mercury in the eudiometer tube, by which he hopes considerably to lessen this probable error.

The samples of air analyzed were collected in the open country in glass vessels with due care as to admixture with the air from the collector's lungs, preserved over mercury, freed from carbonic acid, and exploded with hydrogen, of proved purity, obtained by galvanic decomposition of water. But some samples were collected in clean stoppered and capped bottles, and kept for a short time by inverting the bottle in the cap which had been filled with water. In this case the air was withdrawn for analysis with a Tœpler's mercury pump.

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* The divergence of the second result of February 26th from the first is due to the fact that in the second analysis the hydrogen used was not pure. As none of the sample remained for a third experiment, the second result is given in confirmation of the first. But this pair of results should not be used in computing probable errors.

The table gives in the first column the date, in the second, the mean temperature of the day at this place as determined by three observations. In the third, on the days when analyses were made, the hour of collecting the sample is given, fractions of hours being disregarded. In the last two columns are given the hundredths per cent found by analysis, the figures twenty and the decimal point being suppressed. The figures ninety-six, for instance, in this column mean 20·96 per cent of oxygen. Within the time covered by the analyses now published, there were several well marked great and sudden depressions of temperature, and the figures show the falling off in the proportion of oxygen in the air at these times to be as well marked as the depression of temperature. The deficiency is not proportionate to the depression of temperature; this could not be expected.

It may be said that these analyses were commenced in March, 1878, but in December of that year, a doubt was felt whether it were absolutely certain that in every case the air and hydrogen had been completely mixed before explosion. In test cases, the air and hydrogen had been permitted to diffuse into each other for eighteen hours before explosion, and the results were the same as in the usual course of analysis; but the analyses are not here given, although they contain only evidence perfectly agreeing with that here presented. In all the analyses here printed, the air and hydrogen were known to be thoroughly mixed; they were driven as rapidly as possible through a capillary tube twelve or twenty times. All made between the first and last dates of the table are given without selection, except that some were rejected for obvious instrumental errors.

The remarkable deficiency of oxygen observed on the twenty-sixth of February seems affected with no reason for doubt. On Sept. 16, 1878, two very careful analyses of the same sample gave 20·49 and 20·46 per cent of oxygen. On July 19, and Nov. 10, 1877, Jolly found 20·56 per cent. The Neues Handworterbuch der Chemie, i, 856, cites an analysis of air from the Bay of Bengal showing 20·46 per cent, one of air from near Calcutta, showing 20·39 per cent, and one of air from near Algiers, showing 20·41 per cent. That Jolly and the writer have found air almost as deficient in oxygen as the three last will lessen the probability that the air of the surface of the earth in the Torrid zone is normally poor in oxygen. One of the first cases of a supposed descent of cold air from

ANALYSES OF AIR,

Showing deficiency of Oxygen attending sudden depression of temperature.

WINTER OF 1878–1879.

Date.	Mean Temperature. F.	Hour of taking sample.	Oxygen.	
Dec. 28	---	4 P. M.	98	96
29	14·8			
30	19·3			
31	16·2			
Jan. 1	23·8			
2	7·6	4 P. M.	91	92
“		10 P. M.	90	89
3	—7·2	9 A. M.	90	91
“		1 P. M.	96	97
4	2·2			
5	7·7			
6	13·5	3 P. M.	97	
7	19·3			
8	26·4			
9	16·9			
10	9·6	10 A. M.	96	
11	20·6			
12	26·0			
13	27·9			
14	26·3			
15	25·8			
16	28·5			
17	29·1			
18	---			
19	15·9			
20	9·9			
21	26·0			
22	37·7			
23	28·3			
24	32·5			
25	32·4			
26	23·7			
27	44·9			
28	37·4	9 A. M.	96	
29	31·5			
30	---			
31	28·2			
Feb. 1	18·5	9 A. M.		96
“		9 P. M.	94	94
2	19·8	9 A. M.	91	93
“		9 P. M.	82	80
3	26·8			
4	28·1			
5	31·5			
6	28·3			
7	25·1			
8	28·5			
9	24·0			
10	32·7			
11	54·4			
12	26·5			
13	15·6			
14	5·8			
15	11·1	4 P. M.	88	86
Feb. 16	26·3	9 A. M.	95	
17	25·7			
18	24·1			
19	23·2			
20	18·9	6 P. M.	87	87
21	17·9			
22	---			
23	25·4			
24	21·5			
25	37·1			
26	22·3	3 P. M.	45	50
27	12·8	9 P. M.	77	80
28	24·1			
Mar. 1	38·7			
2	29·7			
3	34·3			
4	37·2			
5	35·9			
6	41·6			
7	34·1			
8	51·0			
9	61·8			
10	58·4			
11	54·4			
12	40·3			
13	39·4			
14	29·3			
15	22·8	9 A. M.	88	84
“		9 P. M.	84	86
16	25·3	9 P. M.	92	92
17	24·5	9 A. M.	89	90
18	24·3			
19	28·7			
20	33·1			
21	32·3			
22	34·6			
23	31·7			
24	40·1			
25	30·1			
26	38·2			
27	35·1			
28	44·8			
29	45·9			
30	33·3			
31	31·9			
Apr. 1	33·7			
2	29·9			
3	{ 25 at 2 P.M. }	9 A. M.	77	79
“		9 P. M.	85	87
4	27·1	9 A. M.	80	80
“		9 P. M.	88	85
5	28·2	9 A. M.	77	77
“		9 P. M.	86	82
6	39·4			

an elevation mentioned by Loomis occurred in the warmer parts of this country. If his theory finds favor, and the writer's conjecture is correct, it will be presumed that the three samples cited in the Handworterbuch from the still warmer regions of the earth were taken in the midst of such a mass of cold air descending from, and retaining the composition of, the upper parts of the earth's atmosphere.

The analyses here printed should not be used in determining the average composition of the air by combining analyses from all sources. Whether the writer's conjecture is correct or not, it has enabled him to select times for taking samples of air varying widely from the average; and to such times his analyses have been commonly limited, only occasionally including a sample of presumably normal air to serve as a check on the abnormal.

Western Reserve College, Hudson, Ohio, June 12, 1879.

ART. XXVIII.—*Principal J. W. Dawson's criticism of my Memoir On the Structure of* Eozoon Canadense *compared with that of Foraminifera;* by K. MÖBIUS, Professor of Zoology at Kiel.*

IF it were true that "the organic character of Eozoon is at present generally admitted," as Dr. Dawson says in his criticism on my memoir, I could have spared myself the trouble of elaborating, and others that of reading, my studies. But every one who has paid attention to this question knows that this statement of Dr. Dawson is not correct. As long as two different opinions about one object in nature are maintained, and on both sides by men whose learning and honesty in the search for the truth cannot be questioned, so long are renewed studies and descriptions of the differently judged object a scientific duty for all who believe that they have the true explanation. For every phenomenon in nature but one thoroughly true explanation is possible. This principle, as stated in my memoir (p. 178), has guided me in preparing it for the scientific public.

Dr. Dawson says further, "As fast as one opponent" (against the organic character of Eozoon) "is disposed of, another appears." And he rises, himself, to dispose of me, the last of the opponents.

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* For Dr. Dawson's paper see this Journal, xvii, 196, March, 1879.

[Thinking that Professor Möbius should have, if he desired, an opportunity to reply to Dr. Dawson's criticism, and that science would profit thereby, we offered him the pages of this Journal, and stated that we should be pleased if he would occupy them and give his views on the subject; informing him, at the same time (in order to remove any objections that might arise in his mind), that there would be no rejoinder in this Journal. Professor Möbius has accordingly prepared for us the article now published. J. D. D.]

No one should be able to do so better than he. It was he who described the *Eozoon Canadense* as an organism; who has, moreover, a very fine collection of specimens of Eozoon, and has studied the Eozoon *in situ* and is fully acquainted with the literature relating to it. I could not, indeed, have wished for a more experienced reviewer, to show me where I had fallen into error and where I had found the truth.

It is Mr. Dawson's belief that few scientific men are in a position fully to appreciate the evidence respecting the organic character of Eozoon; that this is true of the geologists and mineralogists, because they do not yet agree with regard to the nature of the rocks in which it occurs; and of the biologists, because "they are but little acquainted with the appearance of foraminiferal organisms when mineralized with silicates." "Nor are they willing," he says, "to admit the possibility that these ancient organisms may have presented a much more generalized and less definite structure than their modern successors. Worse, perhaps, than all these, is the circumstance that dealers and injudicious amateurs have intervened and have circulated specimens of Eozoon, in which the structure is too imperfectly preserved to admit of its recognition." These are the principal points in the introduction to Principal Dawson's criticism on my paper. He continues: "The memoir of Professor Möbius affords illustrations of some of these difficulties in the study of Eozoon."

I hope Principal Dawson will concede that, in my memoir, there is no evidence that the different hypotheses with regard to the geological character of the strata in which the Eozoon occurs have puzzled me; nor that any previously conceived hypothesis has influenced me in my conclusions. To hypotheses of this kind I have briefly alluded in the last chapter of my memoir where I say: "While excluding Eozoon from the organic world by scientific arguments, it is by no means maintained that in the Laurentian period there may not have existed organisms. It is possible that the graphite of the Laurentian beds may have originated from organisms." These words ought plainly to have shown Mr. Dawson that no geological hypothesis compelled me in advance to deny the organic nature of Eozoon. On the contrary, in the beginning of my studies I hoped to gain conclusive evidence in favor of the organic character of Eozoon, as I have stated in my memoir, chapter VI: "It is to me a source of regret that I cannot say to Messrs. Dawson and Carpenter, who have so kindly aided me in my work, that *Eozoon Canadense* must be considered, from my researches also, a fossil Foraminifer." I quote these words here for the benefit of those readers of Principal Dawson's criticism who are not acquainted with my memoir.

I was familiar with the structure of fossilized Foraminifera, as can be seen from several notations and figures in my paper. Nor was I unwilling to admit that the structure of Eozoon might be different from that of modern Foraminifera, as is evident from the following words in my memoir (p. 188):

"If all the structures of Eozoon, in the same layers and forms that they have in the best specimens circulated by Dawson and Carpenter, were indeed produced by living beings, the living Eozoon must have had a nature totally different from that of all plants and animals we know. If it were possible to prove that Eozoon is a fossil and not a mineral, we must then make two divisions of organic bodies, viz: 1, organic bodies with protoplasmic nature (all plants and animals); 2, organic bodies with eozoonic nature (*Eozoon* Dawson). In the genealogical line, in which the theory of evolution or descent unites all protoplasmic beings, there is no place for Eozoon."

Further, not a single one of all the specimens of Eozoon, which I studied, came from the hands of "dealers or injudicious amateurs," but all directly or indirectly from Messrs. Dawson and Carpenter. This I have said repeatedly in my paper. I am consequently much surprised at the words of Dr. Dawson: "The memoir of Professor Möbius affords illustrations of some of these difficulties in the study of Eozoon."

Why should Principal Dawson write thus about my memoir if he has read it throughout with attention and understanding? It bears full evidence that I had not to struggle in the slightest degree with such difficulties.

But Principal Dawson has read my paper, and he points out *two errors* in it, viz: 1, I have (on p. 180) taken as a figure of full natural size a very large specimen of Eozoon, which Principal Dawson on plate III of his "Dawn of Life" has presented of half the natural size; 2, on the same page I say: "We know specimens of Eozoon which have more than fifty whitish and greenish laminæ," on which Mr. Dawson remarks, that they often have more than a hundred.

For these corrections I offer my sincerest thanks. Other substantial errors he has not mentioned. If he will do so, I shall be further grateful to him. For if in a paper of mine an error is unveiled, the first displeasure I feel in having not been careful enough to avoid making a mistake, is very soon effaced by the satisfaction of seeing the pure and certain truth come forth. No naturalist, in any branch of science, has ever discovered and brought out at once the whole truth in all directions. It is evident that those two mistakes are of no significance in deciding the question whether *Eozoon Canadense* is an organism or not.

But Dr. Dawson writes further (p. 197): "Möbius has had access merely to a limited number of specimens mineralized with serpentine. These he has elaborately studied, and has made careful drawings of portions of their structures, and has described these with some degree of accuracy; and his memoir has been profusely illustrated with figures on a large scale. This, and the fact of the memoir appearing where it does, convey the impression of an exhaustive study of the subject, and since the conclusion is adverse to the organic character of Eozoon, this paper may be expected, in the opinion of many not fully acquainted with the evidence, to be regarded as a final decision against its animal nature. Yet, however commendable the researches of Möbius may be, when viewed on the evidence of the material he may have at command, they furnish only another illustration of partial and imperfect investigation, quite unreliable as a verdict on the questions in hand."

On reading these lines one cannot but be astonished and ask, whether they were written by the same author, who said a few lines before: "Professor Möbius is a good microscopist, fairly acquainted with the modern Foraminifera, and a conscientious observer." This impression he must also have gained from my paper on *Eozoon Canadense.*

Principal Dawson, in saying I have had access "*merely to a limited number of specimens*" of Eozoon, should have stated exactly how many specimens are to be studied to gain a conclusive judgment in regard to its real nature. It has often happened that biologists and paleontologists have had not more than one specimen in hand, or even not more than a part of a specimen, and notwithstanding they were in a position to determine surely its place in the organic kingdom. He says, further: "Möbius has made drawings of *portions* of the structure of Eozoon;" he does not state what structures I have omitted. I have certainly made careful drawings and descriptions of all the Eozoon-structure, which according to Messrs. Dawson and Carpenter corresponds with the chambers, the communications between them, the tubuli of the proper wall of the chambers, and the canal-system in the intermediate skeleton of Foraminifera.

Principal Dawson says again: "Möbius has described these structures with *some degree* of accuracy." It would have been more satisfactory if he had pointed out the imperfections of my descriptions, each one for itself and all without reserve. I should have been grateful for the aid in improving my descriptions of Eozoon.

Principal Dawson evidently apprehends that my "profusely illustrated" paper may convey the impression of an exhaustive study of the subject. That was indeed my purpose. Has he not read or understood my remarks (pp. 178 and 179) in regard to the necessity of many good drawings of all the structures of

Eozoon? Or, had he in writing his criticism the opinion that it would be read by those only who would never see my paper itself?

But how can he venture to say: "The fact of the memoir appearing where it does conveys the impression of an exhausting study of the subject?" A bad paper has never gained the continued assent of the public through the fame of the Journal in which it appeared. In giving my paper to the editors of the illustrious "Palæontographica" I had by no means the intention of gaining for it any higher opinion than it deserves by itself. I wished to bring it before a disinterested and judicious public; besides, I knew that the publisher of the "Palæontographica" would take care to print my drawings very exactly, and he has done so.

After having made these objections in general, Principal Dawson considers "a number of errors and omissions arising from want of study of the fossil *in situ*, and from want of acquaintance with its various states of preservation."

If Principal Dawson demands that nobody should venture to judge of the nature of Eozoon but those who have seen it *in situ*, he claims in favor of his *Eozoon Canadense* an exception over all productions of the accessible world. When writing these lines he overlooked the fact that Mineralogy, Paleontology, Botany and Zoology contain a very great number of universally appreciated memoirs concerning objects which the authors have never seen *in situ.*

It was my intention to study Eozoon from a biological point of view, which is indeed shown in the title of my memoir, viz: "*The structure of Eozoon Canadense, compared with that of Foraminifera, by my own investigations.*"

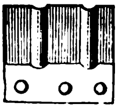
It seems strange that Principal Dawson quotes in his criticism but the first five words of this title. If it were actually so short, many things might have been left out which the real title promises. For my purpose, the examination of Eozoon from a *biological point of view*, I was in a very favorable situation, because a very large number of specimens of *Eozoon Canadense* were at my disposal, which Messrs. Dawson and Carpenter had sent directly to me or to other naturalists.

Can I now be reproached, that I accepted all specimens of Eozoon as genuine, which the two principal defendants of its animal nature had proved! But if Principal Dawson means that my drawings and descriptions were insufficient to show all variations and all degrees of preservation of his *Eozoon Canadense*, I would request him urgently to send me such specimens as will enable me to improve my researches. I shall accept them with my best thanks, study them very exactly, and will bring all I shall find conscientiously before the scientific public.

On p. 187 of my paper I say: "It is impossible to detect in any specimen of Eozoon any spot, from which there could have originated all the serpentine bodies of this specimen, and which therefore might agree with the primary chamber of Foraminifera." When Mr. Dawson, in alluding to these lines, writes (p. 198): "Möbius objects to the impossibility of detecting *regular* primary chambers like those in modern Foraminifera," he has interpolated the word, "*regular*," for the sake of the argument; he adds: "Möbius seems not to be aware that some Stromatoporæ originate in a vesicular irregular mass of cells, and that in Loftusia the primary chamber is represented by a merely cancellated nucleus." From this it is evident, that *not I*, but *Mr. Dawson* has failed here.

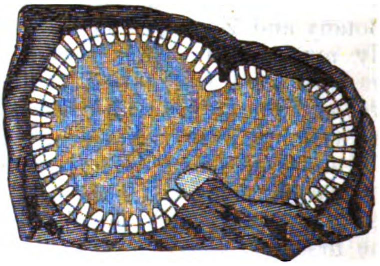
He says further: "With reference to the finely tubulated proper wall of Eozoon, Möbius has fallen into an error scarcely excusable in an observer of his experience, except on the plea of insufficient access to specimens." In writing this, Principal Dawson omitted to state that I studied only those specimens of Eozoon which had come from him and Dr. Carpenter, and that these were indeed very many in number. I beg him to read again the explanations of my drawings, and he will find in many places quoted: "Nummuline tubulation," written from labels by Dr. Carpenter himself on the figured preparations. But Dawson agrees exactly in regard to the "Nummuline tubulation." Both Eozoonists consider the chrysotile veins as the proper wall filled with fine cylinders of silicate. I could not detect in any specimen of Eozoon the slightest traces of such tubuli as Principal Dawson has figured in "The Dawn of Life" (p. 106). I give here a copy of this figure (1). If Eozoon did indeed contain tubuli of such organic regularity, we should have reason enough to agree with him in considering it Foraminiferal, as well as the specimen from Kempten, Bavaria, which Principal Dawson advises me to study (p. 199). I can assure him that I did so before I wrote my memoir, and from prepa-

1.



Cell-wall of Eozoon, when highly magnified; after J. W. Dawson.

2.



Tubuli in the Kempten mineral (× 220).

rations which were kindly forwarded to me by Dr. Hahn at Reutlingen. I add here a drawing of the tubuli in a slice (fig. 2).

Principal Dawson remarks: "That some of Möbius's specimens have contained the proper wall fairly preserved is obvious from his own figures, in which it is possible to recognize both this structure and the chrysotile veins, though confounded by him under the same designation." Why does he not state *what* figures these are, and why has he neglected to give a copy of them in his review, since he has taken some other figures of mine as evidence of the foraminiferal character of Eozoon?

In the same paragraph Principal Dawson speaks in detail of the different difficulties met with in distinguishing the minute tubes. I quote his own words, viz: "When the proper wall is merely calcareous, its structure is *ordinarily invisible*, and it is the same when the calcareous skeleton has, from any cause, lost its transparency, or has been replaced by some other mineral substance. Even in thickish slices, the tubes, though filled with serpentine, may be so piled on one another *as to be indistinct*." Indeed these lines are quite like an esoteric Eozoon mystery; but every true natural doctrine only contains exoteric theses.

Principal Dawson speaks of my description of what he calls the "Canal system." He urges that I was mistaken in thinking that round and regularly branching stalk-like bodies are rather exceptional. I can assure him that I have found in all specimens of Eozoon circulated by Dawson and Carpenter almost only such flat and irregular branched stalk-like bodies as I have illustrated in my figures. It ought to be admitted that as soon as the first objections against the organic character of Eozoon were made, Messrs. Dawson and Carpenter distributed *only good specimens* of Eozoon; and it would be very strange, if just those of their specimens which came into *my* hands had not the genuine structure, but such qualities as speak against the organic nature of Eozoon.

Principal Dawson brings before the readers of his criticism in the figures 1 and 2 (p. 201), two of my drawings of the stalk-like bodies traversing the associated limestone and regarded by Eozoonists as casts of canals. He has chosen just those which differ very little from figures which he and Carpenter have added formerly to their descriptions of Eozoon. Why did he not copy instead of these figures, drawings of the many isolated stalk-like bodies which fill up the "canal systems" and to which I devoted a whole plate? And why does he not speak of those of my drawings which present the casts of the "canal systems" colored by Fuchsin, showing beyond doubt that these are only irregularly curved stalks or plates.

I feel sure that Mr. Dawson will also get the same views of the real forms of the "canal system" if he will only employ my methods. The two figures which he has chosen out of my plates can only serve as evidence for the foraminiferal nature of Eozoon to those readers of Mr. Dawson's criticism, who have never had my memoir in their hands. In selecting these two figures, Mr. Dawson has plainly proved that his views as to the canal nature of the stalk-like bodies are very weakly supported.

"Another objection against the organic nature of Eozoon," says Principal Dawson, p. 200, "Möbius takes to the directions of the canals, as not being transverse to the laminae, but oblique." Here Mr. Dawson did not understand me rightly. I say, chapter IV, p. 184, in regard to the fine tubes of Foraminifera (which are regarded as resembling the chrysotile fibers), that they are usually directed transversely to the inner and outer sides of the chamber-wall, and I show this by figures of Foraminifera, for instance, by the figure of a slice of a Nummuline, which Dawson has copied, fig. 4, p. 201. My remark about the direction of the fine tubes Mr. Dawson refers to his "canal system," to which it does not belong at all. It is therefore not *I*, but *Mr. Dawson*, who makes a mistake.

Paragraph 4 of Principal Dawson's criticism (p. 200), begins with the words: "A fatal defect in the mode of treatment pursued by Möbius is that he regards each of the structures separately and does not sufficiently consider their cumulative force when taken together." Principal Dawson has either not read, or not understood, chapter VI of my memoir. In this chapter my only object was to compare the structures of Eozoon, as a whole, with the structures of Foraminifera. I am convinced that I could not better explain the structure of Eozoon than by describing first each structure particularly, before I compared them all together with the Foraminifera; and all disinterested biologists and paleontologists will agree that there is no better method of treating such an object.

Next follows, in Dr. Dawson's criticism, a *resumé* of his well-known opinions about the organic nature of Eozoon. I will only make a remark about one of the eight points which he makes. He says, point 3: "The general form, lamination and chambers of Eozoon resemble those of the Silurian *Stromatopora* and its allies, and of such modern sessile Foraminifera as *Carpenteria* and *Polytrema*." No one who is minutely acquainted with the structure of Eozoon, Stromatopora, Carpenteria and Polytrema can maintain such an opinion. If Principal Dawson had only compared my figures of *Carpenteria*, *Rhaphidodendron*, and *Polytrema miniaceum*, closely with the structures of Eozoon, he would certainly not have made this statement.

The dear old Polytrema! Ever since the celebrated Professor Max Schultze said that it resembled Eozoon, Polytrema has served ever and anon as evidence for the organic nature of

Eozoon. If Max Schultze had been acquainted with the structure of Eozoon as well as with the structure of Polytrema his histological genius would certainly have prevented him from making such an assertion.

Further on, Mr. Dawson reproaches me for saying that: "Dr. Carpenter and Principal Dawson have leaned to a subjective treatment of Eozoon, representing its structure in a somewhat idealized manner." Where did I say this? On p. 188 I said about their diagrams of Eozoon: "Carpenter and Dawson show clearly by the diagrams of *Eozoon Canadense* that they assume for the supposed living being, which has, in their opinions, formed the shell of Eozoon, the power of producing structures of organic regularity." And, further, I say: "The individual pecularities of diagrams should not exceed the limits of the known variability of the real specimens. But in the Eozoon diagrams of Carpenter and Dawson these limits are exceeded." These are my words. I am convinced that every naturalist who is free from prejudice will agree with me in regard to Carpenter's and Dawson's diagrams.

In the last page of his criticism Mr. Dawson points to his "careful examination and selection of specimens, etc., of Eozoon, in comparison with the works of others who arrive at conclusions in easier ways," and he concludes with the words: "Taken with the above cautions and explanations, the memoir of Professor Möbius may be regarded as an interesting and *useful illustration of the structures of Eozoon*, though from a point of view somewhat too limited to be wholly satisfactory." I here warn every naturalist who has not seen my memoir, not to think that it is an illustration of the organic nature of Eozoon.

The final result of my paper, that the Eozoon can not be a protoplastic organic formation, will be maintained until Principal Dawson declares that all specimens of Eozoon which he has given away are not genuine representatives of his *Eozoon Canadense*, and until he has put into the hands of naturalists who are well acquainted with the structure of Foraminifera the genuine representatives of his *Eozoon Canadense*, which shows that organic nature sustained by Carpenter and himself. If he will kindly send me such representatives of his *Eozoon Canadense*, I will willingly forgive him that he has disappointed me and other naturalists. I will examine those genuine specimens with the same care and conscientiousness; and if I find a true organic structure, I will avow, without hesitation, that the genuine *Eozoon Canadense* was an animal. The aim of all my researches is this: not that I should be the one to find the truth, but that the *truth should be found* and brought to the light. No error will be changed into truth by constantly believing, nor by persistently declaring, it as truth.

Art. XXIX.—*On the Estherville, Emmet County, Iowa, Meteorite of May 10th*, 1879; by Charles Upham Shepard, Emeritus Professor of Natural History in Amherst College.

For the circumstances attending this third fall of aerolites in the State of Iowa since the year 1847, I am indebted to a notice published in the Chicago Times by Mr. S. E. Bemis, and to letters from Mr. Howard Graves and Mr. Henry Barber of Estherville.*

The fall occurred at 5 P. M. on the 10th of May, attended by a terrible explosion, resembling the discharge of a cannon, only louder. It seemed to proceed from a region high up in mid-air; and was followed by a second report, more like a heavy blast. This again was succeeded by one or two more reports, that may have been echoes of the two first. Nearly a minute after, a rumbling sound was heard, apparently passing from the northeast to the southwest. The sky was clear at the time, or only a few fleecy clouds were visible. An observer, Mr. Charles Ega, looking in the direction of the report, could see nothing on account of the sun's rays; but following with his eye the direction of the roaring sound that succeeded, he saw dirt thrown high into the air at the edge of a ravine, one hundred rods northeast of where he was standing. At a like distance, still farther away in the same direction, a similar disturbance of the ground was seen by Mr. Barber. Another witness, Mr. S. W. Brown, living three-quarters of a mile distant, being in the edge of a wood, and having his eyes directed upward at the moment for the inspection of some oak trees, saw a red streak in the heavens; and while looking at it, the explosion took place. It appeared to him, that the meteor was passing from west to east; and that when it burst, there was a cloud at the head of the red streak, which darted out of it like smoke from a cannon's mouth, and then expanded in every direction.

On examining the ravine where a body was seen to strike, a hole in the ground was discovered, twelve feet in diameter and six in depth. It was filled with water. Within this hole, at a depth of fourteen feet below the general surface of the ground, the large mass, weighing four hundred and thirty-one pounds, was found. It had penetrated a stratum of blue clay to the depth of six feet, before its progress had been arrested. The mass measured twenty-seven inches in length, by twenty-two and three-quarters in breadth, and fifteen in thickness. Its surface is described as "fearfully rough," with ragged projections of metal. From one of these a portion was detached, and shaped into a finger-ring. After much searching, there have since been found in the immediate vicinity of the hole, several smaller masses, varying in weight from one to eight ounces; also one mass of four pounds, and another of thirty-two.

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* A short notice of this meteorite's fall, by Professor S. F. Peckham, is given on page 77 of this volume.—Eds.

At the distance of two miles from this spot, in a westerly direction, a mass of one hundred and fifty-one pounds was also discovered. It was imbedded in a dry, gravelly soil, at the depth of four and a half feet. This specimen is in the possession of the University of Minnesota at Minneapolis.

Description of the Meteorite.

The specimens thus far received (for which I am indebted to Mr. Graves), though numerous, are all small, the largest weighing only 147·7 grammes: nevertheless, accompanied as they are with a general description of the main masses, they afford the means of arriving at a tolerably clear conception of the general character of this very remarkable meteorite. It is marked by the unusual prevalence of chrysolite and meteoric iron, the former probably constituting two-thirds its bulk; also by the size and distinctness of the chrysolitic individuals, together with their pretty uniform, yellowish-gray or greenish-black color; and by the ramose or branching structure of the meteoric iron. Nearly one-half of the chrysolite, however, is more massive, approaching fine granular, or compact. Yet in this condition it is still highly crystalline, and difficultly frangible. This portion is of an ash-gray, flecked with specks of a dull greenish-yellow color. The luster is feebly shining. It is without any traces of decomposition; on the contrary, it is throughout a fresh, undecomposed crystalline aggregate. Especially is it observable, that the stony portions nowhere present traces of the oolitic, or semi-porphyritic structure, so common in meteoric stones.

The mean specific gravity of four examples of the stony portion was found to be 3·35. The crust upon this variety is of the usual thickness, black, without luster, and much wrinkled. One of the fragments shows a cavity of half an inch area, completely lined with a shining dark-green glass, as if from the perfect fusion of chrysolite.

The meteoric iron, besides being in ramose branches, is also in enveloping coatings around the chrysolite, somewhat as in the Pallas and Atacama irons. The specific gravity of this aggregate, cleared of the stony part, was 5·97; that of the large specimen of 147·7 grams, was 4·54. The presence of schreibersite in the metal is apparent to the naked eye; also traces of the Widman figures which so constantly attend its presence, and to which they owe their production.

A very remarkable appearance is exhibited by the meteoric iron in some of the specimens. It is the bright silvery whiteness of the metal where it forms a portion of the exterior of the stone. It appears to have been fused and is surrounded on all sides by the black crust, coming from the stony material. It will be interesting to know whether this character prevails over the main mass from which these fragments were separated. If such should be the fact, it would give us a second case in which meteoric iron seen to fall, reached the earth in the possession exteriorly of a high metallic luster. The other instance is that of the Dickson County meteorite, Tennessee, July 30, 1835.

The chrysolite, in large distinct concretions and highly crystalline individuals, deserves a particular notice. Some of these show imperfect crystalline facets, and nearly all the larger ones possess eminent cleavages. In a few instances they are nearly transparent and gem-like. Specific gravity (on 0·77 grams) = 3·50.

The next most conspicuous species present is troilite. This also is in distinct individuals, sometimes as large as a pea. It is highly crystalline, rarely presenting splendent crystalline facets, whose color approaches silver-white. The proportion in which it exists is apparently large, and may equal two per cent.

Next in importance comes the feldspathic mineral, presumably anorthite. It is highly crystalline, white, lustrous and nearly transparent, resembling in these particulars the similar mineral found among the ejecta of Vesuvius.

Among the specimens are two very distinct examples of an opal-like mineral of a yellowish-brown color, which I take to be chassignite. Its luster is resinous, structure imperfectly slaty, to massive and conchoidal. A small granule of chromite occurs in one of the fragments of the massive chrysolite.

Such are the minerals thus far distinguished in the Estherville meteorite. As a whole, it differs widely from the normal meteoric stones. These differences consist, in the first place, in the unusual prevalence of a chrysolite similar to that found in the meteoric irons; secondly, in the large proportion of meteoric iron present, and in the manner in which it is involved with the chrysolite; thirdly in the fresh and highly crystalline condition of all the constituents of the meteorite. Nothing like an aggregation of pulverulent, ash-like grains, more or less rolled into oolitic shapes, so common in meteoric stones, is discernible. The stony portions much more resemble the olivinic rocks of extinct volcanos, particularly those of the Eifel district.

Judging from the specimens in hand, it cannot properly be referred to any group of meteoric stones with which we are acquainted. It would rather appear to be a connecting link between the Litholites and the Lithosiderites, though it may possibly find a place in the Eucritic group of the former, in which case it would form an order by itself.

New Haven, June 27, 1879.

ART. XXX.—*On the Color Correction of Achromatic Telescopes;* by WM. HARKNESS.

ALTHOUGH much has been written on the theory of the achromatic telescope, I am not aware that any attempt has hitherto been made to treat the color correction rigorously as a function of the wave length of the light; and, on that account, much obscurity, and some positive error, has crept into the text books on the subject.

The theory given in the following pages is based upon fundamental equations which neglect the thickness of the lenses, as has always been done heretofore, and which suffice to give the refractive indexes to scarcely more than four places of decimals. All the subsequent operations upon these equations are rigorously accurate; and it would have been useless to attempt greater precision in the refractive indexes, while the thickness of the lenses is neglected. As achromatic telescopic objectives are usually composed of two lenses, rarely of three, and hardly ever of a greater number; it has been thought sufficient to write the equations in the form applicable to triple objectives, but no difficulty will be experienced in extending them to a greater number of lenses, when necessary.

Our fundamental equations are

$$\frac{1}{f}=(\mu-1)\left\{\frac{1}{r}+\frac{1}{\rho}\right\} \tag{1}$$

$$\mu=a+b\gamma^2+c\gamma^4 \tag{2}$$

in which

f = the principal focal distance of any lens.
μ = the refractive index of the lens.
r = the radius of curvature of the first surface of the lens.
ρ = the radius of curvature of the second surface of the lens.
λ = the wave length of the light.
$\gamma = 1 \div \lambda$.
a, b, c = certain coefficients, determined from not less than three properly situated values of μ.

Equation (2) is Cauchy's dispersion formula. Now put

$$\frac{1}{r}+\frac{1}{\rho}=\mathrm{A} \tag{3}$$

and suppose a series of lenses, such that

$$\frac{1}{f_1}=(\mu_1-1)\mathrm{A}_1;\ \frac{1}{f_2}=(\mu_2-1)\mathrm{A}_2;\ \frac{1}{f_3}=(\mu_3-1)\mathrm{A}_3 \tag{4}$$

These lenses being very thin, let them be placed in contact with each other; and let the equivalent focal distance of the whole combination be f. Then, by a well known optical theorem,

$$\frac{1}{f} = (\mu_1-1)A_1 + (\mu_2-1)A_2 + (\mu_3-1)A_3 \qquad (5)$$

Substituting the values of μ_1, μ_2, μ_3, from equation (2), putting

$$\left.\begin{aligned} C &= A_1(a_1-1) + A_2(a_2-1) + A_3(a_3-1) \\ D &= A_1b_1 + A_2b_2 + A_3b_3 \\ E &= A_1c_1 + A_2c_2 + A_3c_3 \end{aligned}\right\} \qquad (6)$$

and arranging the terms according to the powers of γ, we have

$$f = \frac{1}{C + D\gamma^2 + E\gamma^4} \qquad (7)$$

This equation expresses the relation between the focal distance of the combination, and the wave length of the light. It shows that when white light enters an objective there will generally be an infinite number of foci, situated one behind the other, and all contained between the two values of f which correspond to the limiting values of γ. For our purpose, however, it will be more convenient to consider f as the ordinate, and γ as the abscissa, of a curve which we will designate as the focal curve. To investigate its properties, we differentiate with respect to f and γ, and obtain

$$\frac{df}{d\gamma} = -2\gamma f^2(D + 2E\gamma^2) \qquad (8)$$

Putting the left hand member of this expression equal to zero, we find

$$\gamma^2 = -\frac{D}{2E} \qquad (9)$$

Differentiating (8) a second time

$$\frac{d^2f}{d\gamma^2} = 2f^3\gamma^2(2D + 4E\gamma^2)^2 - f^2(2D + 12E\gamma^2) \qquad (10)$$

Substituting the value of γ^2 from (9), this becomes

$$\frac{d^2f}{d\gamma^2} = 4Df^2 \qquad (11)$$

which shows that, so long as D remains positive, the curve is convex toward the objective, and the value of γ given by equa- (9) corresponds to the minimum focal distance.

An achromatic objective, or more accurately, and with greater generality, a corrected objective, is one in which all rays of the kind for which the correction is made are brought to as nearly as possible the same focus. For example; if an objective is corrected for visual purposes, then the rays which produce the greatest effect upon the human eye must all be brought as nearly as possible to the same focus; or, if the objective is corrected for photographic purposes, then the rays which act most energetically upon silver bromo-iodide must all be brought as nearly as possible to the same focus. This condition will evidently be fulfilled when the rays in question have the minimum focal distance; or in other words, when they satisfy equation (9). Thus it appears that this equation determines the correction of the objective, and for that reason it will be called the achromatic equation, and the particular value of γ which satisfies it will be designated as γ_0.

To find the relative values of A_1, A_2, A_3, in a corrected objective, we substitute in (9) the values of D and E from (6). The resulting expression for the middle lens is

$$-A_2 = \frac{A_1(b_1 + 2c_1\gamma_0^2) + A_3(b_3 + 2c_3\gamma_0^2)}{(b_2 + 2c_2\gamma_0^2)} \qquad (12)$$

which shows that this lens must be of the opposite kind from the other two,—that is, if the first and third lenses are convex, the middle one must be concave; or *vice versa.*

To find the equivalent focal distance of the whole combination for the ray λ_0, (9) gives

$$D = -2E\gamma_0^2 \qquad (13)$$

Substituting this in (7)

$$f_0 = \frac{1}{C - E\gamma_0^4} \qquad (14)$$

Replacing C and E by their values from (6)

$$f_0 = \frac{1}{A_1(a_1 - c_1\gamma_0^4 - 1) + A_2(a_2 - c_2\gamma_0^4 - 1) + A_3(a_3 - c_3\gamma_0^4 - 1)} \qquad (15)$$

Substituting the value of A_2 from (12), and putting

$$\left.\begin{aligned} n &= \frac{A_3}{A_1} \\ L &= (a_1 - 1)(b_2 + 2c_2\gamma_0^2) - (a_2 - 1)(b_1 + 2c_1\gamma_0^2) + \gamma_0^4(b_1c_2 - b_2c_1) \\ M &= (a_3 - 1)(b_2 + 2c_2\gamma_0^2) - (a_2 - 1)(b_3 + 2c_3\gamma_0^2) + \gamma_0^4(b_3c_2 - b_2c_3) \end{aligned}\right\} \qquad (16)$$

we obtain finally

$$f_0 = \frac{b_2 + 2c_2\gamma_0^2}{A_1(L + nM)} \qquad (17)$$

The ordinate of the focal curve for the ray λ_1, is the difference between the focal lengths of the objective for the rays λ_0 and λ_1. To find it we have

$$\frac{1}{f_0} - \frac{1}{f_1} = (C + D\gamma_0^2 + E\gamma_0^4) - (C + D\gamma_1^2) + E\gamma_1^4) = D(\gamma_0^2 - \gamma_1^2) + (E\gamma_0^4 - \gamma_1^4) \qquad (18)$$

But

$$\frac{1}{f_0} - \frac{1}{f_1} = \frac{f_1 - f_0}{f_0 f_1} \qquad (19)$$

and putting $f_1 - f_0 = \Delta f_1$, this becomes

$$\Delta f_1 = f_0 f_1 \left\{ \frac{1}{f_0} - \frac{1}{f_1} \right\} \qquad (20)$$

Substituting for the quantity within the brackets, its value from (18); and replacing D and E by their equivalents from (6)

$$\Delta f_1 = f_0 f_1 \{ (A_1 b_1 + A_2 b_2 + A_3 b_3)(\gamma_0^2 - \gamma_1^2) + (A_1 c_1 + A_2 c_2 + A_3 c_3)(\gamma_0^4 - \gamma_1^4) \} \quad (21)$$

Substituting the values of A_3 and $A_2 \div A_1$ from (12) and (16), and putting

$$\begin{aligned} N &= b_1 c_2 - b_2 c_1 \\ P &= b_3 c_2 - b_2 c_3 \end{aligned} \quad (22)$$

we obtain the important expression

$$\Delta f_1 = A_1 f_0 f_1 (\gamma_0^2 - \gamma_1^2)^2 \frac{N + nP}{b_2 + 2c_2 \gamma_0^2} \quad (23)$$

If a star is viewed through a carefully focused achromatic telescope, and if the surface in the focus of the eye-piece is designated as the focal plane: then, of the infinite number of images which equation (7) shows will be formed, some will be situated before, and some behind the focal plane, but only one will coincide exactly with it. The cones of rays which form the images situated before and behind the focal plane will necessarily have a sensible diameter at their intersection with that plane, and their combined effect will be to produce a fringe of colored light around the image of the star, as seen through the eye-piece. This fringe is the secondary spectrum, and its magnitude, for light of any given wave length, will evidently depend upon the value of Δf_1. Hence, to destroy the secondary spectrum, Δf_1 must be made equal to zero. Equation (23) shows that this will be the case for a triple objective when

$$N + nP = 0 \quad (24)$$

or for a double objective when

$$N = 0 \quad (25)$$

As yet no materials have been discovered whose physical properties are such as to satisfy these conditions. We therefore proceed to investigate what form an objective constructed of any given materials must have in order to render the secondary spectrum a minimum.

Substituting in (23) the value of A_1 from (17), we find

$$\Delta f_1 = f_1 (\gamma_0^2 - \gamma_1^2)^2 \frac{(N + nP)}{(L + nM)} \quad (26)$$

In the right hand member of this equation, n is the only quantity which depends upon the form of the objective. Considering it as variable, and differentiating, we obtain

$$\frac{d(\Delta f_1)}{dn} = f_1 (\gamma_0^2 - \gamma_1^2)^2 \frac{PL - MN}{(L + nM)^2} \quad (27)$$

To make Δf_1 a minimum, such a value must be attributed to n as will reduce the right hand member of (27) to zero. This condition gives at once, $n=\infty$; which will be the case when r and ρ are both infinite; as is evident from equations (16) and (3). The objective is then reduced to two lenses, and a piece of very thin plano-parallel glass. As the latter cannot appreciably affect the color correction, it may be dismissed from further consideration; and thus it appears that from any three pieces of glass suitable for making an objective, but not fulfilling the conditions necessary for the complete destruction of the secondary spectrum, it will always be possible to select two pieces from which a double objective can be made that will be superior to any triple objective made from all three of the pieces.

The focal curve being tangent to the focal plane at the point corresponding to the wave length λ_0; if we assume the spherical aberration to be perfectly corrected for light of all degrees of refrangibility; then the image of a star formed upon the focal plane by light of wave length λ_0 will be a point, and the linear semi-diameter of the image of the same star formed by light of wave length λ_1 will be the semi-diameter of the cone of rays of that wave length at the point where it cuts the focal plane. Therefore we have

$$f_1 : \alpha :: \Delta f_1 : s_0^{11} \tag{28}$$

in which α is the semi-aperture of the objective, and s_0^{11} is the required semi-diameter of the cone of rays of wave length λ_1. Combining (28) with (26), we find

$$s_0^{11} = \alpha(\gamma_0^2 - \gamma_1^2)^2 \frac{\mathrm{N} + n\mathrm{P}}{\mathrm{L} + n\mathrm{M}} \tag{29}$$

This is the expression for a triple objective. In the case of a double one, n becomes zero, and (29) reduces to

$$s_0^{11} = \alpha(\gamma_0^2 - \gamma_1^2)^2 \frac{\mathrm{N}}{\mathrm{L}} \tag{30}$$

which shows that in a double objective properly corrected for any given purpose, the linear semi-diameter of the secondary spectrum is absolutely independent, both of the focal length of the combination, and of the curves of its lenses; and depends solely upon the aperture of the combination, and the physical properties of the materials composing it.

If a telescope armed with an achromatic eye-piece is carefully focused upon a star, and then the image of the star is viewed through a prism held before the eye-piece; it will be seen that the eye does not adjust the focal plane tangent to the focal curve, but places it somewhat further from the objective, in such wise that the plane cuts the curve in two points, which we will designate as γ_m and γ_n. For these points we must have

$$\frac{1}{\mathrm{C} + \mathrm{D}\gamma_m^2 + \mathrm{E}\gamma_m^4} = \frac{1}{\mathrm{C} + \mathrm{D}\gamma_n^2 + \mathrm{E}\gamma_n^4} \tag{31}$$

which gives

$$-\frac{\mathrm{D}}{\mathrm{E}}=\gamma_m^2+\gamma_n^2 \tag{32}$$

But by (9) we have

$$\gamma_0^2=-\frac{\mathrm{D}}{2\mathrm{E}} \tag{33}$$

Combining this with (32), we find

$$\gamma_0^2=\tfrac{1}{2}(\gamma_m^2+\gamma_n^2) \tag{34}$$

which gives the relation between γ_0 and any pair of points at which the focal plane may cut the focal curve.

We have next to consider how the value of γ_m can be found; and for that purpose a method partly arithmetical, and partly graphical, seems most convenient. The data required are, the values of Δf for a number of different values of γ, and the relative intensity of the light at each of these values of γ. The values of Δf must be computed by means of equation (26); and the relative intensity of the light may either be determined experimentally, or taken from published tables. For visual intensity, the table given by Fraunhofer may be employed; and for photographic intensity, the curves published by Captain Abney contain all that is required. For the sake of definiteness, let us suppose that the value of γ_m is to be determined for an objective corrected for visual purposes. We begin by laying down an axis of abscissas, and graduating it into a scale of wave lengths. Here, however, it must be observed that the brightness of any part of a spectrum depends not only upon the inherent brightness of the light at that point, but also upon the degree of dispersion employed. As Fraunhofer's determinations of the relative brightness of different parts of the spectrum were made with a flint glass prism having a refractive index of 1·63 for the ray D; and as such an instrument produces much greater dispersion at the violet end of the spectrum than at the red end; it follows that our scale of wave lengths must be, not a scale of equal parts, but such a scale as existed in the spectrum employed by Fraunhofer. The wave length of the brightest ray is approximately 5688, and through that point in the scale, and at right angles to the axis of abscissas, the axis of ordinates must be drawn. Then, from the computed values of Δf, a sufficient number of points must be laid down to determine the focal curve, and that curve must be drawn. At the points whose wave lengths correspond to the principal Fraunhofer lines, lines must be drawn through the focal curve, parallel to the axis of ordinates; the length of each line being proportional to the relative brightness of the spectrum at the point where it is situated, and the center of each line coinciding accurately with the focal curve. Through the extremities of these lines a closed curve must be drawn. The figure thus obtained will be termed the illumination diagram, because it exhibits the amount and distribution of the light at the focus of the objective. The eye will necessarily place the focal plane in the position where this light will produce the greatest effect upon the retina; which is equivalent to saying that the focal plane must pass through the center of gravity of the diagram. Hence, to find the position of the focal plane, we have only to cut out the diagram (which should be drawn upon rather stiff paper), and balance it upon a knife edge held parallel to the axis of abscissas. The reciprocals of the wave lengths of the points of intersection of the knife edge with the focal curve will then be the values of γ_m and γ_n.

The method just explained may be employed to determine the difference between the positions of the principal focus of the same telescope when used for different purposes. For example, if it were required to find the interval between the visual and photographic foci of a telescope, two illumination diagrams would be drawn—one for the visual, and the other for the photographic rays—and the difference between the positions of the focal plane in the two diagrams would be the required difference of foci.

As the magnitude of the secondary spectrum of a star is measured by the semi-diameter (at the point where it intersects the focal plane) of the cone of rays having the maximum focal distance; it follows that in an objective corrected for visual purposes, the secondary spectrum is diminished by the fact that the eye places the focal plane somewhat further from the objective than the apex of the focal curve. To find the amount of this diminution, we remark that for light of wave lengths corresponding to the points where the focal plane cuts the focal curve, the semi-diameter of the cone of rays is zero; while for light of any other wave length, the semi-diameter of the cone of rays, at the point where it intersects the focal plane, is proportional to the distance between that plane and the point of the focal curve corresponding to the wave length of the light. Hence, the effect of moving the focal plane into a position further from the objective than the apex of the focal curve, will be to diminish $s_0{}^{\text{11}}$ by a constant which is numerically equal to the value of $s_0{}^{\text{11}}$ for light whose wave length is that of the point at which the focal plane intersects the focal curve. Modifying equation (30) in accordance with these principles, it becomes

$$s_m{}^{11} = \alpha\{(\gamma_0{}^2 - \gamma_1{}^2)^2 - (\gamma_0{}^2 - \gamma_m{}^2)^2\}\,\frac{\mathrm{N}}{\mathrm{L}} \qquad (35)$$

in which γ_m is the reciprocal of the wave length corresponding to either of the two points in which the focal plane cuts the focal curve; and s_m^{11} is the semi-diameter, at the point where it cuts the focal plane, of the cone of rays whose wave length is λ_1.

The exact nature of the color correction of a telescope can be determined by placing the focal plane in a number of different positions, and observing the corresponding values of γ_m and γ_n. These values being substituted in equation (34), several independent values of γ_0 can be deduced, the mean of which will probably be very near the truth.

The conclusions reached in the preceding pages may be summed up as follows:

1st. From any three pieces of glass suitable for making a corrected objective, but not fulfilling the conditions necessary for the complete destruction of the secondary spectrum, it will always be possible to select two pieces from which a double objective can be made that will be superior to any triple objective made from all three of the pieces.

2d. The color correction of an objective is completely defined by stating the wave length of the light for which it gives the minimum focal distance.

3d. An objective is properly corrected for any given purpose when its minimum focal distance corresponds to rays of the wave length which is most efficient for that purpose. For example, in an objective corrected for visual purposes the rays which seem brightest to the human eye should have the minimum focal distance; while in an objective intended for photographic purposes the rays which act most intensely upon silver bromo-iodide should have the minimum focal distance.

4th. In double achromatic objectives the secondary spectrum (or in other words, the diameter, at its intersection with the focal plane, of the cone of rays having the maximum focal distance), is absolutely independent both of the focal length of the combination, and of the curves of its lenses; and depends solely upon the aperture of the combination, and the physical properties of the materials composing it.

5th. When the focal curve of an objective is known; and the relative intensity, for the purpose for which the objective is corrected, of light of every wave length is also known; then the exact position which the focal plane should occupy can readily be calculated.

6th. It may be remarked incidentally that in an objective corrected for photographic purposes, the interval between the maximum and minimum focal distances is less than in one corrected for visual purposes. Hence, a photographic objective has less secondary spectrum, and is better adapted to spectroscopic work, than a visual objective.

Washington, May 24, 1879.

ART. XXXI.—*Terminal Moraines of the North American Ice-Sheet;* by WARREN UPHAM.

[Continued from page 92.]

BEYOND Block Island the extreme terminal moraine does not rise above sea-level for 35 miles, at which distance in a direction a little to the north of east it reäppears in No Man's Land and Gay Head. Heights of it here and in its farther extent are as follows: No Man's Land, about 150; Gay Head, 100 to 145; about one mile east, near the church, 185; Prospect Hill, the highest on Martha's Vineyard, 295; Peaked Hill, a mile south from the last, 290; other hills, reaching from these five miles to the northeast, 200 to 250; Indian Hill, 245; Sampson's Hill, on Chappaquiddick Island, about 100; highest part of Tuckernuck, about 50; Macy's or Pole Hill, the highest of Saul's Hills, 91; Folger's Hill, a mile east from the last, 88; and Sankaty Head, the highest point of Nantucket Island, 105. The cliffs of Gay Head, at the west end of Martha's Vineyard, expose a section four-fifths of a mile long, composed at the top of the unstratified terminal moraine, five to forty feet thick, filled with abundant bowlders of all sizes up to twenty feet in diameter. This rests on fossiliferous beds,* probably of Miocene Age, which dip from 20° to 50° northerly throughout the section, and present a most striking succession of brightly-colored clays, sands and gravel, varying from black to red, brown, gray and white. Gay Head township, reaching three miles to the east, has a very uneven surface of glacial drift in small elevations and depressions, strown with frequent bowlders, but apparently underlain by Tertiary clay and sand at no great depth.

In the next eight miles this moraine forms high parallel ranges of hills, very irregular in contour, which extend northeastward through Chilmark and the northwest part of Tisbury, occupying a width of one to three miles. Their surface is generally till, with very abundant bowlders; but occasionally, as at the top of Prospect Hill, it is modified, consisting mainly of water-worn gravel and sand. The black, red and white Tertiary clays underlie these deposits in the hills, and are exposed in the cliffs along the northwest shore to the east side of Lumbard's Cove, eleven miles from Gay Head. Upon the south side of Prospect and Peaked Hills they extend to heights 225 and 250 feet above the sea.

The southeast half of Martha's Vineyard consists of modified drift without bowlders, lying in extensive level plains, twenty-five to fifty or sixty feet above sea. Along the south shore these plains are indented by numerous ponds, which are only separated from the ocean by a beach, and the shores of the ponds are again indented by long and narrow arms or coves, from the head of which dry channels, similar to those described on Long Island, extend across the plains in a northerly course. The road from West Tisbury to Edgartown crosses several of these depressions, one of which, known as Quampachy Hollow, may be taken as an example. This starts from the head of Oyster Pond, a narrow arm of the sea, which stretches two miles north from the beach by which it is now shut in. The dry hollow, diminishing from twenty-five to ten feet in depth, and from 300 to 100 feet in width, prolongs this valley at least three miles to the north. Near Vineyard Haven and Oak Bluffs, north of these plains, and on Chappaquiddick Island, the modified drift, sometimes sprinkled with bowlders, is heaped in gently sloping hills, 50 to 100 feet high, which appear to have been formed at the margin of the ice-sheet.

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* Described in Hitchcock's Geology of Massachusetts, 1833 and 1841; in Lyell's Travels in North America in 1841–2, vol. i, pp. 203–206; and in this Journal, I, vol. xlvi, pp. 318–320.

Thence the line of terminal moraine is continued in Muskeget and Gravelly Islands, which however are only low banks of gravel and sand. On Tuckernuck Island it appears again in small hills, which in part are unstratified, with plenty of bowlders, the remainder being modified drift. Nantucket is composed almost wholly of stratified gravel and sand. The line at which the ice-sheet appears to have terminated is marked in the west part of this island by gently undulating hills, forty to fifty feet high, composed of stratified drift, which, however, differs from that of the plains on the south in having here and there bowlders up to ten feet in diameter embedded in it or lying on the surface. The course of this line is from Eel Point, north of Maddequet Harbor, by Trot's Hills to the town. Eastward it continues on the same course in the Shawkemo and Saul's Hills to Sankaty Head. The portion of this series called Saul's Hills, two miles long and a half mile wide, is of very irregular contour, with steep and abruptly changing slopes, forming hills, ridges, mounds and small enclosed basins, some of which contain ponds. The material is stratified gravel and sand, upon and in which are scattered bowlders, varying up to ten feet in diameter.

Sankaty Head, at the east shore of the island, affords a section across this range.* A quarter of a mile south from the light-house, the order of deposits, beginning at the base is as follows: brown sandy clay to about twenty feet above sea; ferruginous sand and gravel, four feet; white sand, four feet; yellow sand enclosing masses of blue clay, one foot; ferruginous gravel and sand, with abundant shells, two feet; a bed of serpula, mixed with sand, about two feet; gravel and sand again, thickly filled with shells, two feet; fine white sand, about ten feet; the common yellow sand and fine gravel of the modified drift, about forty-five feet, its top being at ninety feet; coarse gravel, three feet; ferruginous sand, one foot; changing above into a former surface soil, one foot thick; overlain by three feet of dune sand, which forms the present surface, ninety-eight feet above sea. The highest part of the bank is midway between this and the light-house. From a comparison of the species contained in these two shell-beds, Professor Verrill estimates that the temperature of the sea at this place was lowered 15° between the times in which they lived. The layer of coarse gravel which occurs here at the height of ninety feet, is continuous for a half-mile from this point both to the north and south, varying from three to eight feet in thickness. About half of its rock-fragments are rounded, these being of all sizes up to one foot through; the rest, which are rough and angular, range up to two feet, and rarely to four feet, in diameter. This bed has its greatest thickness and is coarsest at the highest portion of the bluff, where it closely resembles till. The old surface of black soil and the present surface of dune sand are also continuous along the same distance. An eighth of a mile south from the shell-beds, the bluff falls to a hollow about sixty feet above the sea, and in this depression the blackened layer becomes a bed of peat, two feet thick, containing numerous stumps and roots of trees and covered by two feet of sand. The rocky stratum, the old surface soil, and the overlying sand thus cap the bluff for more than a mile, in which its height falls from 105 feet at the middle to about 35 feet at each end. Below the rocky layer it consists of fine modified drift and pre-glacial beds. This succession tells of a period when the sea had about its present temperature; next it becomes much colder; sand and fine gravel are accumulated to a depth of more than fifty feet, probably brought by rivers from the summer-meltings of the ice-sheet; this finally reached its outmost limit, overspreading the north half of the island; at its retreat the coarser materials which it held were dropped; forests sprang up, as the climate became mild again; and, lastly, the sea has eaten away the east portion of these deposits, while the sand of its shore has been swept by the wind over their top.

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* The Post-pliocene beds at the base of this section, and their fossils, are described by Professor A. E. Verrill and Mr. S. H. Scudder, in this Journal, III, vol. x, pp. 364–375.

The whole-south side of Nantucket Island consists of nearly level plains of gravel and sand, twenty to sixty feet above the sea. This expanse, reaching more than ten miles from west to east, with a width varying from one to three miles, is broken by frequent hollows which extend approximately from north to south, like those already noticed on the similar plains of Long

Island and Martha's Vineyard. Narrow ponds, to the number of a dozen or more, having the same height with the ocean, fill the entire course of these depressions, or occupy their lower end next to the south shore.

The Second Terminal Moraine.—A later series of morainic hills extends along the north shore of Long Island for forty-five miles eastward from Port Jefferson to its extremity at Orient Point. Their heights are approximately as follows: Strong's Neck, close east of Port Jefferson, 100 to 200 feet; Mount Sinai, at school-house, and Miller's Place, each about 150; Noah Jones' Hill, 1½ miles east from Miller's Place, 200; Pine Hill, one mile farther east, 175; Blue Point Hills, one mile southeast from last, 150; hills near Wading River village, 150 to 200, the highest of which, at Mr. D. M. Tuthill's, a mile east from the village, commands a very fine view; hills, partly of dune sand, north of Baiting Hollow, known by the names of "Horse in the Bank," Horton's Bluff, and Friar's Head, about 150; at Northville, 125; Jacob's, Cooper's and Mattituck Hills, 125 to 150; Manor Hills, extending east from Mattituck Inlet, 100 to 150; Horton's Point, 70; highest points for the next seven miles, extending by Greenport, about 50; Brown's Hills, north of Orient, 110 and 160. East from the light-house on Horton's Point, these deposits, though not rising in prominent hills except at Orient, are in many places unstratified, with an abundance of large angular bowlders, which are of all sizes up to twenty-five feet in diameter. This terminal moraine overlies stratified gravel, sand and clay, which contain no bowlders; as is well shown in the bluffs, 50 to 100 feet high at the north side of Brown's Hills, where the very coarse morainic till is five to twenty feet thick, and forms the entire surface of these hills. The last two miles of this shore from near Brown's Point east to Orient Point, are all stratified gravel and sand twenty to forty feet high, strown in only a few places with bowlders; being a part of the plains which skirt the south side of the moraine. Its hills probably once existed here at a little farther north, but they have been washed away by the sea. The same action is apparent throughout the whole extent of this series on Long Island, so that many of these hills have lost more or less from their north side, and stand as half-eroded barriers which are still falling slowly before the encroachment of the waves. The greater portion of this series, extending more than thirty miles from Port Jefferson to Horton's Point, is composed, like the extreme moraine on the south, of obliquely stratified sand and coarse gravel, with occasional bowlders, which are sometimes of enormous size. One of these, about thirty feet long, lies at the north side of the road, 1½ miles west from Wading River. Two others of equal size are seen close to the road in Setauket village. The largest block yet found on Long Island lies much farther west, at about a mile southeast from Manhassett, and is, according to measurement by Mr. Lewis, fifty-four feet long, forty feet wide, and sixteen feet high.

This later moraine is separated six to ten miles, on Long Island, from that formed at the extreme line reached by the ice-sheet, and the area between them is occupied by extensive plains, the Peconic Bays, and Shelter Island. This series of plains resembles that of southern Long Island, in that both slope southward from terminal moraines on their north side, and are alike crossed by ancient water-courses which are now dry. The plains associated with the second terminal moraine begin at Syosset, about twenty-five miles west from Port Jefferson, and it is not improbable that the second moraine may be represented in the irregularly scattered hills, composed of modified drift with bowlders here and there, which lie at their north side along this distance. For the first ten miles the plains vary from one to two or three miles in width, having a height from 100 to about 150 feet above sea. Their greatest altitude appears to be at East Northport station. Here they pass beyond the north spur of the Dix Hills and expand to the south, attaining a width of five miles, which continues without much variation to Riverhead. In Smithtown considerable portions of these plains have been removed by the erosion of streams since the Glacial period. Their height along their north side here and in Brookhaven is 150 to 100 feet above sea, from which the general slope southward is about ten feet to the mile. Near the east line of Brookhaven is a notable series of ponds, reaching four miles, and lying in depressions of one of the old lines of drainage. These are called the West Row Ponds, and are known in their order from north to south as Long Pond, Big and Little Tar-kiln, Pease's, Duck, Sandy, Grass, and Jones' Ponds, extending to the Peconic River at a mile west from Manorville. Two miles eastward in Riverhead are the East Row Ponds, a similar series, including in the same order the two Jackson Ponds, Ice, Worthington and Fox Ponds. Northeast from Fox Pond is a tributary series, including Sand, Mud and Cranberry Ponds. Several other valleys, not containing ponds and of similar character with those of the southern plains, extend southward from the vicinity of Baiting Hollow and Northville. On the north branch of the island these plains diminish from four miles to about one mile in width, their height being sixty to thirty feet at the north, from which they slope to the shores of Peconic and Gardiner's Bays. The hilly character of Shelter Island, which varies from 50 to about 180 feet in height, being composed of stratified sand and gravel with occasional bowlders, indicates that it was of similar origin with the hills of modified drift in the two moraines between which it lies. During the retreat of the ice-sheet it would appear that exceptionally large deposits were accumulated by its rivers here and at Gardiner's Island.

The continuation of the second moraine beyond Orient Point is to the east-northeast in Plum and Fisher's Islands, and from Watch Hill through the south part of Westerly, Charlestown and South Kingstown in Rhode Island, to near Point Judith. On Plum Island it forms hills about 100 feet high, abundantly covered with bowlders; but a considerable tract on the south side of this island is a low plain of modified drift, free from bowlders and sloping southward. Gull Island is a remnant of this plain which was formed in front of the terminal moraine. Fisher's Island, about seven miles long, is a conspicuous remnant of the moraine, being composed of the same coarse glacial drift with Brown's Hills and Plum Island. Its elevations vary from 100 to nearly 200 feet in height, the most prominent being Mount Prospect, North Hill, and Chocomount. Portions of the low plains are preserved on its south side for a mile from its west end, and again for a third of a mile between two ponds near the middle of the island.

In the State of Rhode Island this moraine is well developed for seventeen miles, and its whole course may be finely seen from the carriage road in going from Watch Hill through Charlestown and Perryville to Wakefield. After the first three miles, which are mostly on the north side of the range, this road lies for fifteen miles at the south foot of these hills, which are so irregular and broken in contour and so rough with their profusion of bowlders that they cannot fail to impress the observer with the remarkable features of an entirely unmodified terminal moraine. The width of this series of deposits is from one to two miles, and some of its highest points, not noticeable from this road, consist of stratified gravel and sand without bowlders. Such are Chin and Cranberry Hills in Westerly, and the tops of Indian Burying and Sand Hills in Charlestown. These rise 100 to 150 feet above sea, and probably no points of the range reach to 200 feet. Fort and Village Hills in Westerly, the "Old Mountain" and Bunker Hill in Charlestown, and Broad Hills in South Kingstown, are unmodified portions of this series. The margin of land on its south side, averaging perhaps a mile in width, consists mainly of gently undulating modified drift, with occasional bowlders, its only expanse in plains being for about three miles in the southeast part of Charlestown. Within one to two miles northeast and east from Perryville, several ponds occur among the hills, ridges and knolls of the moraine. At this part of its course it appears to turn to the southeast, passing into the sea two miles west of Point Judith. This angle corresponds to a similar one which was probably formed in the extreme moraine at Block Island, whence it also seems to have extended first to the southeast, in which direction very rocky fishing-ground is found at a distance of ten miles from that island.

The next appearance of the northern moraine is in the Elizabeth Islands, where the position of Cuttyhunk, Penikese and Nashawena Islands corresponds to that of No Man's Land, Gay Head and the hills of Chilmark in the southern moraine, indicating that angles occur again in them both, respectively at Penikese and at Gay Head. Heights of the later moraine on the Elizabeth Islands and Cape Cod, are as follows: highest portion of Penikese, about 100 feet; of Cuttyhunk, Nashawena, Pasque and Naushon Islands, about 175; the Quisset Hills, west of Falmouth village, about 150; station of the United States Coast Survey, a mile east of West Falmouth, 198; the Ridge Hills, extending thence to the angle of this series near North Sandwich, 150 to 200 feet; southwest from Sandwich village, about 225; Bourne's Hill, a Coast Survey station, two miles south-southeast from Sandwich, the highest point of the whole series, 297; the Discovery Hills, including the last and extending eastward, 250 to 150; Shoot Flying Hill in Barnstable, about 200; German's Hill in Yarmouth, 138; Scargo Hill in Dennis, 166; railroad summit at Brewster station, 125; and Mill Hill in Orleans, about 150.

This moraine forms the entire chain of the Elizabeth Islands, fifteen miles long, with an average width of one mile. Their contour throughout is very irregular in roughly-outlined hills and ridges of variable height, enclosing many crooked and bowl-shaped hollows, which often hold small ponds. Their material is glacial drift with abundant bowlders of all sizes up to twenty or thirty feet in diameter. The surface exhibits all the characteristic features of the upper till, being loose, yellowish in the color of its detritus, and with its bowlders almost invariably angular. This deposit also appears to form the greater part of the cliffs upon the shores of these islands. At the northeast end of Naushon, however, in deepening an old well from forty-five to sixty-seven feet, only the dark and compact lower till, or ground-moraine, was found.

The trend of this chain of islands is about east-northeast, but on the peninsula of Cape Cod the same belt of hills, continuing with its width, contour and material unchanged, bends within a few miles to a course nearly due north. A railroad cutting thirty feet deep in these deposits near Wood's Hole, and shallower sections on the Quisset Hills, show two or three feet of yellowish till at top succeeded below by light gray till, equally coarse but apparently more compact, with some of its fragments planed and striated. The latter was probably accumulated beneath the ice-margin, while the former was dropped by its melting. After holding its way northward ten or twelve miles, reaching to a point about a mile south of North Sandwich, the range turns at a right angle to a course a few degrees south of east. Some portions of it in this vicinity are strown with bowlders, but mainly, as shown on the roads which cross these hills southwest and south from Sandwich village, at the highest portion of the entire series, they consist of stratified gravel and sand, with bowlders rare or entirely wanting. There is also a change to a more simple contour, with fewer irregular hills and hollows. From its angle the range extends about thirty-five miles to the east shore of the cape. Through Sandwich and Barnstable it lies about a mile south of the railroad, consisting in the latter town of hills 100 to 200 feet high, apparently formed of modified drift, with frequent bowlders embedded in it and scattered upon its surface. In Yarmouth the series is somewhat broken, and the railroad crosses it upon a sand plain a little west of German's Hill. South of Dennis Pond and for one and a half miles northeast from German's Hill to Follin's Pond, it is very well shown in exceedingly rocky, low hills. Next it appears to suffer an offset of about two miles to the north, being represented by Scargo Hill, which is modified drift with only few bowlders. Thence it runs a little north of east six miles to Brewster station, where it is again crossed by the railroad. Through most of this distance it is very rocky, some of its blocks being twenty to thirty feet or more in diameter. Its further course is mostly modified drift with occasional bowlders, passing east-northeast to Mill Hill, Orleans village, and the southeast side of Town Cove, beyond which it is concealed beneath the ocean.

The angle of this range at North Sandwich shows that the portion of the ice-sheet on the west and that on the east pushed against each other here, the motion and slope of each being directed toward its line of frontal moraine. The medial moraine produced where their slopes came together north from the angle of their terminal line, is presented in Rocky, Manomet and Pine Hills, which form a gigantic ridge in the east part of Plymouth, four miles long from north to south, with a continuous height 300 to 400 feet above the sea. Abundant angular bowlders of all sizes up to twenty feet in diameter strow its surface. At the north end of this ridge the sea has undermined its base, forming a steep slope sixty feet in height. A section here showed twenty feet of upper till, yellowish, with abundant large and small bowlders, nearly all of them angular, underlain by lower till, dark bluish gray, with small glaciated stones, exposed for twenty feet vertically but concealed below. The bed of bowlders which forms the shore at this point came mostly from the upper stratum, and their sharp corners and edges have since been worn away by the waves.

On Cape Cod, as on Long Island, Martha's Vineyard and Nantucket, we find south of the line of morainic hills an area of stratified gravel and sand without bowlders, forming extensive plains which slope very gently southward. These are fully ten miles wide from north to south in Sandwich, Falmouth and Mashpee, and thence to the east they have an average width of five miles. From the southwest limit of this area at Falmouth village, the traveler who follows the road along the south side of the cape for thirty miles sees only level plains, twenty-five to forty feet above the sea, with occasional hollows and valleys, most of which are occupied by ponds and brooks. The north edge of this area, next to the terminal moraine, consists of more elevated plateaus, 50 or 75 to 200 feet in height. From this line there is a continuous slope southward, scarcely perceptible, but declining in the five to ten miles of its extent to within twenty-five to forty feet above sea. This north portion of the plains is marked by frequent hollows of large extent, which contain ponds 50 to 100 feet below the general surface. A fine idea of the slope of this deposit of modified drift is obtained in a journey from Sandwich to Greenville, Ashunet Pond and Falmouth. The ascent of 200 feet or more from sea-level to the highest point of the road is accomplished in two miles, bringing us to a point where Bourne's Hill, the highest on Cape Cod, is within a half mile to the east; while close at the west is the Great Hollow, about 100 feet deep and perhaps a half-mile wide, enclosed on all sides by the hills and high plains. Without descending more than twenty feet below its highest point, the road next enters on a plain of gravel and sand, and thence extends seven miles before crossing the first hollow which is at Ashunet Pond. Beyond this point it crosses numerous depressions that are or have been water-courses; but there is no break in the continuity of the plains, which in about twelve miles descend by a gradual slope from the height of 200 feet to sea-level.

These plains of Cape Cod are also like those previously described in being indented by narrow arms of the sea which reach one to two miles inland, filling the lower end of long depressions that continue across the plains to the north, being either dry or occupied by small streams. These channels are best shown on Cape Cod in Falmouth and eastward to Cotuit harbor, being in the region directly south from the angle of the terminal moraine and from its highest hills, which in this portion of its course are composed mainly of modified drift;

in other words, they occur most abundantly where the drainage from the melting ice-sheet must have been greatest, including all the floods poured down from the ice-fields along the line between Falmouth village and North Sandwich, those that converged toward the angle of the ice-margin, and those which brought down its vast frontal hills of gravel and sand along several miles eastward.

Extensive portions of the terminal moraines were deposited, as we have seen, by rivers which flowed from the surface of the melting ice when a warmer climate returned. On the south side of these the plains have their greatest width and height, while on the north we also find extended areas of modified drift, which show that the glacial floods continued to be poured down to the same portions of the ice-margin during its retreat. Thus on Long Island the area north of the extensive moraine from the Narrows to Roslyn consists almost wholly of undulating unmodified drift with abundant bowlders, while farther eastward it is stratified gravel and sand with few bowlders. Wherever angles occurred in the terminal front of the ice its surface had converging slopes, which would be likely to produce extraordinary fluvial deposits. This may explain the origin of the thick beds of stratified drift which form nearly the whole of Block Island, and of the plains in South Kingstown, R. I., which extend six miles north from the angle of the second moraine, reaching from Tucker's and Worden's Ponds to the north line of the township. The plains south of the moraines at their angles near Vineyard Haven and North Sandwich are notably due to the debouchure of glacial rivers at these points; and when the ice-sheet retreated from its second moraine, the floods which it discharged formed a most irregular belt of gravel and sand in ridges, hills, plateaus and hollows of every shape, but generally with a north-to-south trend, through a distance of nearly twenty miles to the north and north-northwest, reaching from its angle at North Sandwich through Plymouth to Kingston. West and north from these kames, the greater part of Plymouth County consists of nearly level or moderately undulating deposits of modified drift, 50 to 150 feet above sea, which reach continuously from the angle of the terminal moraine on Cape Cod more than thirty-five miles to Hingham, on the south shore of Massachusetts Bay. Another and perhaps more remarkable series of fluvial deposits was supplied from the melting ice-sheet to form Nantucket, the hills which rise 75 to 125 feet above sea in Chatham, the southeast township of Cape Cod, and the north portion of this peninsula beyond Orleans, which consists entirely of modified drift from 50 to 175 feet above sea.

The first recognition of the terminal moraines of southeastern

Massachusetts was by Mr. Clarence King,* who examined Naushon Island and pronounced it, with the similar formation continuing on Cape Cod, to be a series of deposits accumulated at the margin of the continental ice-sheet. The same conclusion has been announced by the geologists of Wisconsin and New Jersey respecting the series which cross those States. At these lines the border of the ice appears to have remained nearly stationary through a long period, in which the materials that it contained were being continually brought forward and deposited.† In many places these would be pushed into very irregular heaps and ridges by slight retreats and advances of the ice-margin. At the same time we should also expect that thick beds of ground-moraine would be gathered beneath the ice near its termination. The withdrawal of the glacial sheet would then leave these deposits as upper and lower till, one overlying the other in a long but broken and undulating range. In many parts of these series, however, the materials brought by the ice have been covered by modified drift brought by glacial rivers; so that the three divisions of the drift join to form the terminal moraines. No similar series of drift deposits seems to have been discovered north of the second here described, and we may conclude that in general the retreat of the ice-sheet did not admit sufficient pauses for their formation.

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* Proceedings of the Boston Society of Natural History, vol. xix, p. 62.

† In Long Island and throughout New England, the materials that make up the drift are uniformly derived from the north, the greater part of them being from the nearest formations in that direction, while nearly all the rock-fragments are represented by ledges within fifty miles. The most remote origin required by any bowlders or pebbles found in the drift of New Hampshire during the recent geological survey of that State is about eighty-five miles. Respecting the origin of bowlders at the north end of Manomet Hill in Plymouth, Dr. Edward Hitchcock, the State Geologist, reported that this locality shows nearly every variety of granite. syenite and porphyry, found along the coast northward as far as the extremity of Cape Ann. Dr. C. T. Jackson, in his report on the geology of Rhode Island, says that the greater part of the bowlders found on Block Island are porphyritic granite such as occurs in place at Point Judith and Kingston. twelve and twenty miles distant at the north. Sir Charles Lyell, in his "Travels in North America," quoting in substance from one of Professor Mather's annual reports, says of Long Island: "At its eastern extremity the bowlders are of such kinds of granite, gneiss, mica slate, greenstone and syenite, as may have come across the Sound from parts of Rhode Island, immediately to the north. Farther westward, opposite the mouth of the Connecticut River, they are of such varieties of gneiss and hornblende slate as correspond with the rocks of the region through which that river passes. Still farther west, or opposite New Haven, they consist of red sandstone and conglomerate, and the trap of that country; and lastly, at the western end, adjoining the city of New York, we find serpentine, red sandstone, and various granitic and crystalline rocks, which have come from the district lying immediately to the north."

Excepting the pre-glacial deposits which have been mentioned, and a small area of gneiss and hornblende schist at Long Island City and Astoria, the whole of Long Island, Block Island, Martha's Vineyard, Nantucket, the Elizabeth Islands, and the peninsula of Cape Cod, consist of drift deposits which owe their accumulation, as has been here shown, to the action of the ice-sheet and its rivers in amassing them at its termination.

It remains for us to notice briefly the probable extent and equivalency of these terminal accumulations of the ice-sheet, both to the east and west. Agassiz believed that the fishing banks or submarine table-lands, which lie at a distance of 100 to 200 miles east and southeast from Cape Cod, Nova Scotia and Newfoundland, are such glacial deposits. On the other hand, it has been recently learned that fragments of fossiliferous rock,* apparently of Miocene age, are brought up from the sea-bottom on George's Bank, Banquereau and the Grand Bank, by the coralline growths attached to them becoming entangled with fishermen's lines. These indicate that this coast, 1,000 miles in extent, is bordered by submerged Tertiary formations, similar to those that occur above sea-level in the Southern States, as had been already suggested by Professor C. H. Hitchcock,† before this discovery. Although it now seems likely that these older deposits form the principal basis of the fishing banks, it is clear that the opinion of Agassiz was part of the truth; for besides the fossiliferous fragments many of granites and schists are also obtained by the fishermen. Furthermore, the course of the extreme terminal moraine that crosses New Jersey, Long Island, Block Island, Martha's Vineyard and Nantucket, has its line of continuation in these remarkable submarine banks. It is probable, therefore, that they consist, somewhat like Gay Head, of Tertiary strata covered with their own and foreign detritus brought by the ice-sheet.

The later moraine of Cape Cod, the Elizabeth Islands, southern Rhode Island and the north shore of Long Island, was formed after the ice had retreated from its farthest limit, but while it still terminated eastward beyond the present coast-line. This halt in its departure was extended along the entire margin of these ice-fields to the west for a distance of more than 2,000 miles. In the interior of the United States the extreme limit of glacial action has not yet been found to be generally marked by extraordinary deposits, but a most notable series of terminal moraines north of this line and probably contemporaneous with that of Cape Cod is found, as recently shown by Professor Chamberlin,‡ stretching across Ohio, and represented in southern Michigan, in the Kettle Moraine of Wisconsin, and the Leaf Hills of Minnesota; while its farther continuation seems to be in the Coteau des Prairies and the Coteau de Missouri of Dakota and British America, reaching northwestward, according to Mr. G. M. Dawson,§ to the North Saskatchewan

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* Described by Professor Verrill in this Journal, III. vol. xvi, p. 323.

† Appalachia, vol. i, p. 13; and Geology of New Hampshire, vol. ii, p. 21.

‡ "On the Extent and Significance of the Wisconsin Kettle Moraine," in Transactions of Wisconsin Academy of Science, 1878, with maps.

§ Quarterly Journal of Geological Society, vol. xxxi, pp. 614–623, with map.

River, 350 miles west of Winnipeg Lake. These deposits, like the moraines of southern New England, are made up entirely of drift materials, partly unstratified with abundant bowlders and partly stratified gravel and sand, in hills 100 to 300 feet high, of very irregular contour, with many enclosed hollows, and occupying a width of from one to thirty miles. They lie upon the uneven surface of the rocky strata, being continuous across valleys and ranges of highland, which in Wisconsin undulate 800 feet in vertical height; while the elevation of this entire series of terminal moraine varies from sea-level in the region that has been here described to 2,000 feet above it at the north line of Dakota.

In the Western States the front of the ice-sheet is shown by Professor Chamberlin to have been lobed, producing acute angles in its terminal moraine, with medial moraines extending northward from them; corresponding to which, we find a deflection of ninety degrees in the series of morainic hills on Cape Cod, with the massive medial moraine of Manomet and Pine Hills a few miles farther north. The same lobed character appears also to have marked the ice-sheet at its greatest extent, making angles similar to those of a later period in its frontal line, and even enclosing a large driftless area in Wisconsin. It is now possible to draw two pictures in our mind of this glacial sheet: the first, when it reached its farthest boundary, probably coinciding nearly with the course of the Columbia, Missouri and Ohio Rivers, and the south coast of New England, while a part of Wisconsin and adjacent States was an oasis of verdure surrounded by its desert of ice; the second, when it had yielded a portion of its ground, but rallied again to a sturdy resistance before being fully put to flight.

ART. XXXII.—*New Observations on Planetoids;* by C. H. F. PETERS. (Communication to the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., August 10, 1879.)

I TAKE pleasure in communicating the following planet observations:

(77) *Frigga.*

1879.	Ham. Coll. m. t.	α. app.	δ. app.	(log. p.″Δ.)		No. comp.
July 17.	$14^h 39^m 5^s$	$21^h 32^m 7^s·38$	−17° 44′ 43″·9	0·168	0·884	11
" 19.	12 51 10	30 48·57	17 51 1·7	$0·160_n$	0·884	10
" 20.	11 14 52	30 8·64	17 54 9 9	$0·372_n$	0·880	10
" 21.	13 6 3	29 21·22	17 57 51·4	$9·853_n$	0·873	12
" 24.	10 14 32	27 9·46	18 7 49·8	$0·688_n$	0·853	10
" 28.	13 19 5	23 47·04	18 22 51·7	9·804	0·889	5
Aug. 9.	12 9 18	21 13 2·44	−19 5 48·2	9·453	0·892	10

(200) [discovered July 27.]

1879.	Ham. Coll. m. t.	α. app.	δ. app.	(log. p.″Δ.)		No. comp.
July 27.	$14^h 51^m 44^s$	$21^h 42^m 46^s \cdot 78$	$-15° 37' 58'' \cdot 8$	0·417	0·869	10
" 28.	14 15 31	41 59·83	15 39 36·7	0·239	0·874	10
" 30.	13 55 43	40 21·57	15 42 59·5	0·159	0·875	10
Aug. 9.	11 21 41	21 31 30·22	−16 0 45·3	$0 \cdot 218_n$	0·876	10

To the planet (199), found on July 9th, as mentioned in the last number of the Journal, I have given the name *Byblis.*

Frigga, as is known, had been searched for in vain for many years, though it had come twelve times in opposition since its discovery, Nov. 12, 1862. There existed nine observations of it made by myself at its first apparition, distributed over ninety-four days; further, three observations, made by Professor Tietjen in April, 1864, after opposition, and one by the same on January 21, 1868, which, however, Professor Tietjen later has doubted, that it perhaps was another object. From the fact, that in at least three of the oppositions I have searched with carefully prepared charts without finding any trace of the planet, I am led to suspect some kind of variability of light-reflecting power, be it atmospheric or arising from the shape. And I find, that, in communicating my observations in 1863 to the Astron. Nachr. (No. 1423), I added then the following note: "From the mean of the estimates the magnitude of the planet in the *mean* opposition results 13·0. Remarkable is the whiteness of the light with which it was shining, and though but a luminous point, the image presented a certain neatness. This was very striking in comparing it on the same evenings, therefore independently of the state of the air, with Feronia, which was not far off." Moreover, in 1864 Professor Tietjen, as he orally communicated to me, estimated the magnitude much larger than the computation had given it. Frigga, therefore, needs watching, as perhaps it may give us some insight into the physical structure of the planetoids and their atmospheres.

When it was re-discovered, on July 16th, its position differed about 6° in right-ascension and 2° in declination from the place rigorously computed with regard to perturbations, etc. The motion ascertained and the situation in the orbit plane, however, made at once probable the identity. For making more sure of this, I computed from the observations of July 17th and 20th a circular orbit, which gave

$$\Omega = 4° \ 5', \qquad i = 2° \ 23', \qquad \log a = 0 \cdot 4425,$$

while for Frigga we have

$$\Omega = 2° \ 1', \qquad i = 2° \ 28', \qquad \log r = 0 \cdot 431,$$

therefore quite the same, the apparently larger difference in the longitude of the node arising only from the small inclination.

ART. XXXIII.—*Observations on the genus* Macropis; by W. H. PATTON.

HERMANN MÜLLER found the females of the European *Macropis labiata* Panz. upon the flowers of *Lysimachia vulgaris* only, while the males occurred also upon the flowers of *Oenanthe fistulosa*, *Rhamnus frangula*, and *Rubus fruticosus.*[*] This is the basis upon which Sir John Lubbock has made and repeated the statement, that "the species visits exclusively *Lysimachia vulgaris.*"[†] Yet Dufour had previously taken both sexes upon *Alisma Plantago*, and Schenck had taken either one or both sexes upon *Bryonia*, *Rubus cæsius*, *Cirsium arvense* and *Picris.* Subsequently, Mr. John B. Bridgman has taken the male upon *Cirsium arvense*,[‡] and upon *Lysimachia*, Mint and Marsh Potentilla, and the female upon *Cirsium arvense* and *Lysimachia.*[§] I have taken the female of the American species upon *Lysimachia ciliata*,[‖] *Rhus glabra* and *R. typhina*, and *Archangelica hirsuta;* and the male upon *Rubus villosus* and *Cornus paniculata.*

Yet there appears to be some peculiar relationship between the *Macropis* and the *Lysimachia.* Collecting in 1874 and 1875, I observed that the *females taken upon other flowers had no pollen masses* upon their legs, and were indeed upon another quest. Mr. Bridgman (l. c., 1878, p. 22) observed that the females taken on *Cirsium arvense* had no pollen. Can it be that the young live upon the pollen of *Lysimachia* only, just as other insects are restricted to the foliage of particular plants?

Hermann Müller (l. c., p. 248), observing that the pollen was collected upon the tibiæ of these bees in thick *moist* balls, and unable to find any honey in the flowers of *Lysimachia vulgaris*, was led to believe that the bees pierced the cellular tissue of the flowers with the *ligula* for the juices with which to moisten the pollen. This act of the bee seems to me both impossible and unnecessary. The ligula is too weak, and, if we are to look to the *Lysimachia* for a solution of the problem, it is well to ask whether the glands with which the filaments and base of the corolla are beset may not furnish the nectar. In the American *L. ciliata*, *L. quadrifolia* and *L. stricta*, and on the filaments at least of the European *L. vulgaris* the glands are very numerous. But upon the flowers of *stricta* and *quadrifolia* the *Macropis* has not yet been found, although the flowers have been often watched; it seems, therefore, that the glands afford no attraction. We must conclude that it is with nectar that the pollen is moistened; and as it has been my good fortune to distinctly observe a female *Macropis* sucking nectar from the flowers of *Rhus glabra*, it is, evidently, from these and other flowers that the *Macropis* obtains the honey for the food both of itself and its young.

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[*] Die Befruchtung der Blumen durch Insecten, pp. 348 and 463 (1873).

[†] Belfast Address, 1874; Nature, vol. x, p. 425, and British Wild Flowers in Relation to Insects, p. 21. The inconsistency of his statement appears when he says (British Wild Flowers, p. 126) that "*Lysimachia vulgaris* produces no honey," and the question arises in the mind of the reader: where do the bees get the honey upon which they must live?

[‡] Newman's Entomologist, Aug., 1876, p. 158.

[§] Ibid., Jan., 1878, vol. xi, p. 22.

[‖] The group of Lysimachias containing *L. ciliata* has recently been set apart as a distinct genus, *Steironema* Raf., by Professor Gray (Proc. Am. Acad., vol. xii, p. 62) because of differences in the æstivation of the corolla, but for our present purposes, *Tridynia* (containing *stricta* and *quadrifolia*), *Lysimachia* (containing *vulgaris*) and *Steironema* may be treated together under the name *Lysimachia.*

But why does the *Macropis* moisten the pollen as it is collected? This is an unusual habit. The social bees moisten it in order that it may be retained on the pollen plates. The Scopulipede and Gastrilege bees retain the dry pollen with the hairs forming the pollen brushes. The *Lysimachia* pollen is not of so dry a nature that hairs would not hold it. An altogether new interest was given to the genus *Macropis* by Hermann Müller's observation that it alone of all the solitary bees of Germany moistened the pollen as collected, thus economizing in the expanse of hairs upon the legs.* The retaining hairs upon the posterior legs of *Macropis* are unusually short. By moistening the pollen they are enabled to retain much larger masses than they otherwise could. Such, also, is the habit, as I have observed, with the allied American genera *Scrapter*, *Calliopsis*, and *Perdita* (*P.* 8-*maculata* Say); and Fritz Müller has recorded the same habit for *Centris*, *Tetrapedia* and *Epicharis* in Brazil,† although in these latter genera the scopa is long.

On account of the close resemblance which *Macropis* bears to the higher bees, Shuckard (British Bees) was led to believe that it would be found to agree with them in their noisy flight also. But repeated observations in the field, under the most favorable circumstances, have satisfied me that their flight is perfectly silent. Yet Shuckard is not correct when he says the other *Andrenidæ* are mute, for I have observed that certain species of *Colletes*, *C. armata* mihi and *C. compacta* Cress., and possibly, some of the larger species of *Andrena*, make, during flight, a distinct hum much like that of the honey-bee.

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* L. c., p. 47, and Anw. d. Darw. Lehre auf Bienen, p. 22 (1872).

† Nature, vol. x, p. 103. These observations by Fritz Müller are open to doubt. In *Centris*, as in our native genera *Diadasia* (n. g.) and *Melissodes*, the hairs of the scopa are conspicuously plumose, and the pollen would have a matted appearance even when dry. It can be stated with confidence that, even if the pollen is slightly moistened by these bees, it is not formed into a paste, as it is by the social bees.

Up to the present time no French* or English author has questioned the validity and naturalness of the two groups, *Abeille* and *Pro-abeille*, into which Réaumur divided all the bees. Kirby adopted this classification, employing the names *Apis* and *Melitta;* Latreille adopted it under the names *Apiariæ* and *Andrenetæ;* and all subsequent authors have employed the same classification, either under these names or under Leach's family names *Apidæ* and *Andrenidæ.* Yet the only characters given for separating the *Apidæ* and *Andrenidæ* which are not entirely erroneous are:

Apidæ; labium longer than mentum, basal joints of labial palpi elongate, labium slender and not flattened.

Andrenidæ; labium shorter than mentum, basal joints of labial palpi not unlike the following joints, labium flattened.

But in the genus *Scrapter* (placed among the *Andrenidæ*) the palpi are precisely as in *Calliopsis* (placed among the *Apidæ*), and, as I have observed, the labium in repose is of precisely the same length—in both extending to the tip of the basal joint of the palpi. The greater breadth of the labium in *Scrapter* can alone determine to which family it belongs, and this difference in breadth is imaginary rather than real. Moreover, in the genera *Megalopta* and *Oxystoglossa*, and some groups of the genus *Nomia* (genera placed among the *Andrenidæ*), the labium is as slender as in the *Apidæ;* and in the genus *Hyleoides* (placed among the *Andrenidæ*) the joints of the labial palpi are proportioned just as in certain of the *Apidæ.*

Rejecting, therefore, the families *Andrenidæ* and *Apidæ*, and without proposing, at present, a more natural classification for the ANTHOPHILA, *Macropis* may be removed from connection with the short-tongued bees and placed between the *Andrenoides* and *Scopulipedes.* In the greater number of its characters it is allied to the *Andrenoides*, but in single characters of great value it bears relationship to other very diverse groups. With the *Andrenoides* it agrees in the venation of the anterior wings, which differs from that of *Scrapter* and *Calliopsis* in the pointed marginal cell only, in the cleft claws of the female, and in the habit of moistening the pollen as collected. With *Andrena* it agrees in the form of the tongue and palpi. With the *Scopulipedes* it agrees in the short anal lobe of the posterior wings and in general appearance. In the form of the basal joint of the posterior tarsi of the female it agrees with none but the social bees, which also have the habit of moistening the pollen as collected.

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* As Lepeletier failed to recognize the *Bees* as a natural group, he cannot be said to have presented any classification of them.

MACROPIS Panz. (1809).

Ocelli in a slight curve; face slightly narrowed beneath; clypens not elevated, yellow in the male; labium transverse, entire; mandibles stout, obtusely bidentate; maxillary palpi 6-jointed, the sixth and one-half of the fifth joints extending beyond the apical lobe of the maxillæ; labium lanceolate, one-third the length of the mentum, the latter narrowing toward the base, the paraglossæ small; joints of the labial palpi decreasing in length successively, the basal joint equal in length to the second and third taken together. The flagellum in the female sub-clavate, the first joint ovate, the second narrowed toward the base and one-third longer than the first joint, the third and fourth joints equal and when taken together shorter than the second joint, the apical joint obliquely truncate; in the male the first joint of the flagellum is globose, the second scarcely longer than the first, the third scarcely one-half as long as the second, the fourth about equal in length to each of the following joints, the flagellum not clavate but longer than in the female. The anterior wings have two submarginal cells, the second receiving both recurrent nervures, the origin of the first recurrent nervure far beyond the origin of the cubital nervure; the stigma of good size; submarginal bullæ six, two on the first transverse nervure, one on the second, one on the first recurrent nervure, two on the second; basal lobe of the posterior wings extending beyond the middle of the submedial cell. Both sexes have the tarsal claws cleft and a distinct enclosure at the base of the posterior tibiæ. Posterior femora of the male swollen; posterior tibiæ in both sexes robust; basal joint of the posterior tarsi of the female quadrate, flattened, the upper angle not produced, the second joint attached at the lower angle; the posterior tibiæ and the basal joint of the posterior tarsi of the female clothed with a short, dense probescence upon which the pollen is collected in moist masses; basal joint of the posterior tarsi of the male armed with a regular comb of long teeth projecting from the inner margin of the lower face. Sixth segment of the abdomen of the female with a smooth enclosure on the disk. The seventh segment in the male with a triangular pyramidal projection on the disk, the apex of the projection obtuse, the anterior and longest side polished.

ART. XXXIV.—*Additional Remains of Jurassic Mammals;*
by O. C. MARSH.

BESIDE the two mammals from the Jurassic beds of the Rocky Mountains already described by the writer,* two other specimens have recently been brought to light, from the same locality and horizon. Both are lower jaws, and apparently both pertain to the genus *Dryolestes*, and furnish important characters to distinguish it. In one of these specimens, the angle of the lower jaw is strongly inflected, thus indicating its marsupial nature. The other proves that the genus is quite distinct from *Didelphys*, as there were at least four premolars. The last lower premolar is compressed and trenchant, and not like the molars.

This specimen differs from the jaws of *Dryolestes priscus*, in being more slender, less curved, and less compressed. The symphysial surface is long, and only moderately roughened. The fourth lower premolar is in perfect preservation. It has two fangs, and the crown is very sharp, and much compressed. There is a slight tubercle on the front margin, and a low distinct heel on the posterior border.

The following measurements are from this specimen:

Space occupied by four lower premolars, ...	6· mm
Depth of jaw below first premolar, ...	2·5
Depth of jaw below fourth premolar, ...	3·
Width of jaw below fourth premolar,............	2·
Height of crown of fourth lower premolar,.... ..	2·

The species represented by this specimen may be called *Dryolestes vorax.* The animal appears to have been rather smaller than *D. priscus.* The only known remains are in the Yale Museum.

Yale College, New Haven, August 8, 1879.

POSTSCRIPT.—Since the above was in type, another lower jaw has been obtained from the same locality and horizon as those already noticed. This specimen is quite distinct from those described from this country, and in some respects resembles the genus *Triconodon* of Owen, from the Jurassic of England. The molar teeth have each three pointed cones, as in that genus. In the present specimen, however, there are four lower molar teeth, instead of three. The middle cone on each tooth is the largest, while in *Triconodon* they are nearly of the same size.† The last lower molar of the present specimen is only about half as large as those before it.

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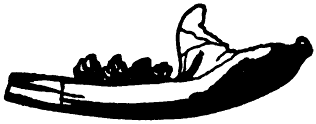
* This Journal, vol. xv, p. 459, 1878, and vol. xviii, p. 60, 1879.

† From *Phascolotherium*, with which it agrees more closely, the present genus may be distinguished by the greater number of teeth.

A striking feature in this jaw is the coronoid process, the anterior margin of which forms a right angle with the ramus, immediately behind the last molar. The angle of this jaw is much extended backward, but not perceptibly inflected. The condyle is low, and but slightly above the dental series.

The figure below gives the outline and general features of this specimen.



Right lower jaw of *Tinodon bellus*, Marsh. Twice natural size.

The principal dimensions of this specimen are as follows:

Space occupied by eight posterior teeth,.........	10· mm
Space occupied by four posterior molars, ...	6·
Distance from last molar to posterior end of jaw,	9·
Height of coronoid process above base of jaw,...	7·
Depth of jaw below last lower molar, ...	2·5
Depth of jaw below last premolar,...............	2·

This specimen indicates a new genus, which may be called *Tinodon*, and the species *Tinodon bellus*. The animal thus represented was apparently an insectivorous marsupial,* and in size somewhat smaller than those above noticed.

Yale College, August 16, 1879.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Spectrum of Ytterbium.*—LECOQ DE BOISBAUDRAN having received from Marignac a portion of his new earth ytterbia, has submitted it to spectroscopic examination. By using the chloride in solution in water, and the induction spark, he obtained a beautiful and distinctive spectrum formed for the most part of bands grouped between the solar lines D and F. Almost all of these bands are shaded from the left toward the right, the spectrum being so placed that the red end is at the left of the observer. The following are the bands observed, their positions being given in scale numbers: (1) Well marked band, slightly shaded from left to right, of intensity β; the left border nebulous at $103\frac{3}{8}$, the apparent center at $104\frac{4}{5}$. (2) Feeble band a little shaded from left to right, its apparent center at $107\frac{1}{8}$. (3) Well marked and strongly shaded band, of intensity α; left border sharp at $109\frac{1}{2}$,

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*** The elevated coronoid process, and the absence of inflection at the angle, suggest the possibility that this jaw may have belonged to a placental mammal. The latter character, with others of importance, indicate a distinct family, which may be called *Tinodontidæ*.**

the middle at 110⅛, and the right and ill-defined edge at about 111⅘. (4) Well marked band, notably shaded from left to right, of intensity δ_1; left edge slightly nebulous at $113\frac{1}{10}$, the middle at 114¼, and the ill-defined right edge at 115¾. (5) About 116⅗, nebulous beginning of a band with two maxima, of intensity δ_2, the whole being well-marked, the principal brightness beginning at about 118, the first and strongest maximum about 119, and the middle of the second maximum at 121¼. Near 122⅛ is the very ill-defined right edge of this band, which is united to the one next following by a slightly luminous background. (6) Band a little more feeble than that at 107⅛ and notably shaded; its left edge, somewhat nebulous, being at 123⅙, its middle about 124⅛, and its very nebulous right edge near 126. (7) Well marked band a little stronger than δ_1 at 114¼ and strongly shaded from left to right, of intensity γ; left edge sharp at 126⅛, the middle being at $127\frac{1}{20}$ and the right edge, ill-defined, at 129. (8) Band sensibly shaded, of intensity ε; easily visible, but distinctly more feeble than δ_1 at 114¼; left nebulous edge at $130\frac{1}{20}$, the middle at 131 and the right ill-defined border at 132¾. (9) Feeble band a little more nebulous on the right than the left edge, its apparent middle at 134; united to the following band by a slightly luminous background. (10) Band very nebulous on both borders, about two divisions broad, notably more marked than 134, and a little stronger than 107⅛; the apparent middle and maximum of light is at 135½. Bands 134 and 135½ together are easily visible. (11) Very weak nebulous band 1½ divisions broad, the middle being about 138. On the scale of the instrument, the solar lines read as follows: B 77⅘, C $83\frac{7}{10}$, D 100, E 121⅘, F 141¾, G 180⅘. Though not at all necessary to establish ytterbium as a new element, the author thinks that the existence of this specific emission spectrum is interesting and may be of service as a means of recognizing this metal, especially in the absence of more precise knowledge of its chemical properties.—*C. R.*, lxxxviii, 1342, June, 1879. G. F. B.

2. *On Nitrification.* — WARINGTON has published a second paper upon nitrification, giving the results of experiments made with the primary object of ascertaining the influence of light and temperature, and also of variations in the composition and concentration of the solutions, upon the process, as well as the rate at which the nitrification progresses and the relation of the nitric acid produced to the ammonia consumed. The importance of the conclusions reached warrants us in giving them at some length. They are as follows: 1. A solution of ammonium chloride, fully supplied with plant-food, will not nitrify if germs be excluded. 2. Such a solution containing calcium phosphate and potassium sulphate, but no organic salt or calcium carbonate, will not nitrify even when seeded. 3. Such a solution, supplied with sulphates and phosphates of potassium, calcium and magnesium, with cane sugar, will not nitrify, even when seeded. 4. Such a solution containing potassium tartrate in addition to phosphates and sulphates, may nitrify when seeded, but the nitrification takes place

very slowly, the salifiable base required, being furnished by the gradual decomposition of the tartrate. 5. Nitrification takes place speedily only when an excess of salifiable base, such as calcium carbonate, is present. 6. Nitrification may occur in solutions in which calcium salts are apparently absent. 7. A proportion of organic carbon (as tartrate) to nitrogen (present as NH_4Cl) equal to 3 : 10 by weight suffices for the purposes of nitrification, and probably even less would be sufficient. 8. Solutions containing as much as 640 milligrams NH_4Cl per liter can be completely nitrified, though the limit of concentration up to which nitrification is possible has not yet been ascertained. 9. Nitrification is not produced by the growth of mould which takes place in a solution containing tartrates. 10. It is not produced by growth of bacteria; at least bacteria may flourish in solutions of composition suitable for nitrification, without nitrification taking place. 11. Light certainly hinders nitrification; this is shown by every experiment save one. In twelve experiments out of thirteen, it is prevented or greatly delayed by exposure to light, or rather to alternate light and darkness. Evidence is yet wanting, however, that the nitrifying ferment is killed by light. In nitrification in the light, nitrites are abundant, even in weak solutions, and are very permanent. 12. Nitrification does not take place at the temperature of 40° C. Prolonged exposure to this degree of heat destroys apparently the ferment. 13. The addition of a small quantity of nitrifying solution to an ammoniacal solution of suitable composition is not immediately followed by perceptible action; a period of rest, often of considerable length, precedes the active work of the ferment. Whether this is due to the necessity of multiplying the germ to produce the effect or to the existence of the germ in a passive condition, is not yet settled. 14. Increase in the concentration of the ammoniacal solution lengthens the period of incubation. 15. Increase of temperature within certain limits greatly reduces the length of the period of incubation, it being shorter at 30° than at 20°. 16. The period of actual nitrification, which succeeds the period of incubation, increases with the concentration of the ammoniacal solution, and if the temperature be fixed, its length varies nearly as the degree of concentration. Strong solutions require rather less time in proportion to their strength than weak ones. 17. The period of actual nitrification diminishes greatly in length by rise in temperature; though it is not yet proved to be shorter at 30° than at 20°. 18. From 16 and 17, it follows that the average rate of oxidation increases up to a certain point with rise of temperature and is also somewhat increased with increasing concentration of the solution. 19. The rate of oxidation is not uniform throughout, the process of nitrification beginning slowly, then increasing in rapidity and after reaching a maximum, diminishes again toward the close. 20. The product of the nitrification is not uniform, sometimes nitrous and sometimes nitric acid being produced. A purely nitric fermentation has occurred only in the case of cold dilute solutions nitrified in the dark. With strong solutions, or at elevated temperatures, or kept in the light, the nitrification is wholly or chiefly nitrous. Cold dilute solutions, in which nitrification is long checked by the absence of a salifiable base, also assume the nitrous fermentation on introducing such a base. 21. It does not appear that the production of nitrous acid is due to a deficiency of available oxygen; at least this is not a sufficient explanation for all the facts. It seems rather to depend on the condition of the ferment. 22. Nitrites produced during nitrification sometimes pass into nitrates with astonishing rapidity during the final stage of the process and before the ammonia has entirely disappeared. Under other circumstances they remain unchanged for a long time after the ammonia is all consumed. Light is apparently a condition which prevents nitrites from turning into nitrates. 23. The nitrifying ferment in certain conditions seems capable of producing nitrous acid only and is incapable, even in the dark, of converting nitrites into nitrates. 24. The whole of the ammonia is not finally obtained as nitric acid, the largest proportion so obtained being about 96 per cent; the mean of ten experiments being 93·7 per cent. In one exceptional experiment only 84·7 per cent was produced. 25. A solution of potassium nitrite remains, for a long time at least, without change, even in presence of tartrates, phosphates and calcium carbonate. But now, if a small quantity of a solution in which nitrites have been changed into nitrates, be added, the oxidation to nitrate is rapidly effected. This conversion takes place apparently only in the dark.—*J. Chem. Soc.*, xxxv, 429, July, 1879. G. F. B.

3. *On the Chemical Constitution of Alkali-metal Amalgams.*—BERTHELOT has investigated the question of the chemical composition of the amalgams which mercury forms with the alkali-metals. A series of these amalgams was prepared, some liquid, some solid, and treated with dilute hydrochloric acid, the heat evolved being measured. At the same time the quantity of the alkali-metal present was determined by analysis. The experiment was always made between 16° and 18°, the quantity of amalgam used being such that the variation of temperature in the calorimeter was between 1·5° and 4°. Beginning with a liquid amalgam containing 0·335 parts K to 100 parts Hg, or $Hg_{116}K_2$, the heat set free by the solution of one atom of K (39·1 grams) in dilute HCl, was 35·8 calories, and hence the heat evolved by one atom of K uniting with Hg was 26·2 calories. With 0·65 per cent K, or $Hg_{61}K_2$, still liquid though mixed with crystals, the heat in the former case is 31·3 and in the latter 30·2. With 1·34 per cent K, or $Hg_{29}K_2$, a pasty amalgam, the numbers are 27·8 and 33·7. With 1·85 K ($Hg_{20·6}K_2$), 27·25 and 34·2, the amalgam being solid. With 2 per cent K ($Hg_{19·2}K_2$), 26·7 and 34·8. With 3·40 ($Hg_{11}K_2$), 31·80 and 29·7. With about 8 per cent K, 41·2 and 20·3. With 8·2 K ($Hg_{4·4}K_2$), 40·7 and 20·8. With 11·85 K ($Hg_{2·9}K_2$), 46·2 and 15·3. Hence it appears that the heat of formation of these amalgams increases at first to a maximum and then diminishes again. This

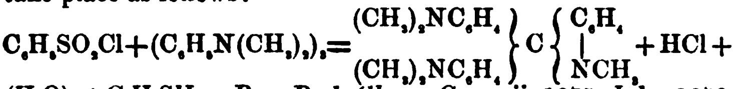
maximum corresponds to a definite and crystallized amalgam analyzed by Crookewitt and by Kraut and Popp, containing 1·6 per cent K and having consequently the formula $Hg_{12}K$. Hg_{12} liquid $+ K = Hg_{12}K$ evolves 34·2 calories; or 27·5 calories if the Hg be solid; values comparable to those of combinations formed with powerful attractions, and lowering the heat of oxidation of K in its amalgams to +48 calories. If this amalgam be now dissolved in four times its weight of mercury, we have $26·2-34·2=-8$ calories absorbed, a value of the same order as is given by the solution of saline hydrates. These results point out the existence of other solid and crystalline amalgams of potassium. Sodium acts similarly in amalgams, the maximum heat being 21·1 calories for one atom Na corresponding to 1·88 per cent Na ($Hg_{12}Na$) a solid, crystalline amalgam analyzed by Kraut and Popp. This gives for the heat of oxidation of Na when dissolved in Hg 56 calories. The attraction of K and Na for oxygen when free, is inverted in their amalgams. Hence the anomaly that sodium in an amalgam will displace the potassium in dissolved potassium hydrate.—*C. R.*, lxxxviii, 1335, June, 1879. G. F. B.

4. *On the Action of Dehydrating Substances upon Camphoric acid and its amides.*—In the hope of producing the nitrile of camphoric acid, which though an isomer of nicotine, is not, since the latter is a tertiary base, identical with it, **Ballo** has studied the action of dehydrating agents upon the camphoryl-amide of Laurent. According to the analogy with similar bodies, this amide under the influence of dehydration must split into the nitrile and water thus: $C_8H_{14}\left\{\begin{matrix}CONH_2\\CONH_2\end{matrix}\right.=(H_2O)_2+C_8H_{14}\left\{\begin{matrix}CN\\CN\end{matrix}\right.$. So also camphoramic acid $C_8H_{14}\left\{\begin{matrix}CONH_2\\COONH_4\end{matrix}\right.=(H_2O)_3+C_8H_{14}\left\{\begin{matrix}CN\\CN\end{matrix}\right.$; and ammonium camphorate $C_8H_{14}\left\{\begin{matrix}COONH_4\\COONH_4\end{matrix}\right.=(H_2O)_4+C_8H_{14}\left\{\begin{matrix}CN\\CN\end{matrix}\right.$.

For the preparation of the amide, he at first passed ammonia gas into a solution of camphoric oxide in alcohol. But the alcohol was not entirely free from water and only ammonium camphorate resulted. The syrupy mass, heated with eight or ten times its weight of fused zinc chloride, gave an oily distillate consisting mainly of the hydrocarbon C_8H_{14}, which the author calls campholene and regards as identical with that obtained by Gille from campholic acid. This experiment shows that under this influence camphoric acid decomposes exactly as oxalic acid does: $C_8H_{14}\left\{\begin{matrix}COOH\\COOH\end{matrix}\right.=C_8H_{14}+CO_2+CO+H_2O$. In a second experiment, the amide was attempted by acting on camphoryl chloride with ammonia. The product of the reaction was again a syrup, which, distilled with phosphoric oxide gave a yellow oil, boiling for the most part between 260° and 280° and having the composition of a polyterpene $C_{20}H_{32}$. From its origin, he called it camphoterpene. The third experiment was like the first, especial care being taken to free the alcohol completely from water. Ammo-

nium camphoramate was the result. Distilled alone, it gave camphorimide $C_8H_{14}\left\{\begin{matrix}CO\\CO\end{matrix}\right\}NH$. This body, distilled with zinc chloride yielded campholene and camphoterpene only, the resulting amide being saponified by the zinc chloride and the phosphoric acid. Ammonium camphoramate itself, distilled with phosphoric oxide directly, gave the desired nitrile mixed with campholene. Recrystallized from alcohol, it was obtained as a colorless crystalline body, odorless when pure and quite similar in appearance to the imide. Ballo closes his paper with some theoretical deductions, in which he formulates camphor as a tertiary alcohol $C\left\{\begin{matrix}(C_9H_{15})'''\\OH\end{matrix}\right.$, the carbinol of the trivalent radical C_9H_{15}; in which case borneol is the secondary alcohol $C\left\{\begin{matrix}(C_9H_{16})''\\H\\OH\end{matrix}\right.$ and menthol the primary alcohol $C\left\{\begin{matrix}(C_9H_{17})'\\H_2\\OH\end{matrix}\right.$.—*Liebig's Ann.*, cxcvii, 321, June, 1879.
G. F. B.

5. *A new Synthesis of Methyl-violet.*—Hassencamp has described a new synthesis of methyl-violet. When a mixture of one part of pure benzene sulphochloride and two parts of dimethyl-aniline is warmed in a flask on the water bath, reaction takes place readily and a deep blue liquid results, becoming deeper and more violet continually until after some hours a thick mass is left having a strong metallic luster. The reaction goes on with great uniformity and no gas is evolved. The behavior of the new color to fibers first suggested that methyl-violet had been formed. On boiling out with water, the presence of phenyl sulph-hydrate is proven. Since the maximum yield is from one molecule of the sulphochloride and three of dimethyl-aniline, the reaction must take place as follows:



$$C_6H_5SO_2Cl+(C_6H_5N(CH_3)_2)_3=\left.\begin{matrix}(CH_3)_2NC_6H_4\\ \\(CH_3)_2NC_6H_4\end{matrix}\right\}C\left\{\begin{matrix}C_6H_4\\|\\NCH_3\end{matrix}\right.+HCl+$$

$(H_2O)_2+C_6H_5SH$.—*Ber. Berl. Chem. Ges.*, xii, 1275, July, 1879.
G. F. B.

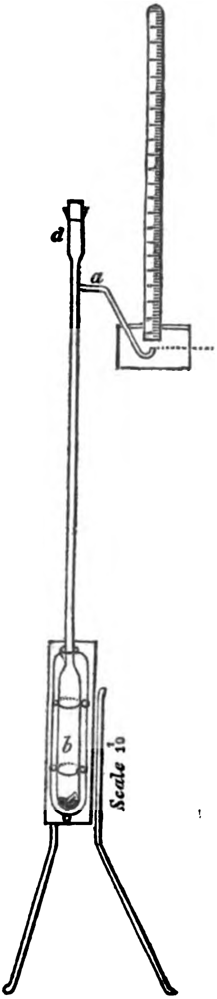
6. *On the Alkaloids of Japanese Aconite Roots.*—Wright, in connection with Luff and subsequently with Menke, has examined the alkaloids contained in some aconite roots recently imported into England from Japan. The conclusions of the paper are: (1) Aconite roots from Japan are tolerably uniform in character and considerably richer in active crystallized alkaloids as well as non-crystalline bases than *A. napellus.* (2) The active crystalline alkaloid is, as Paul and Kingzett suppose, different from both aconitine and pseudaconitine, though closely allied to both, especially the former. (3) Only one crystallized alkaloid could be isolated from each of three different batches of roots. This has the formula $C_{66}H_{81}N_2O_{21}$. (4) This alkaloid, to which

the name japaconitine is assigned, breaks up upon saponification into benzoic acid and a new base japaconine, $C_{26}H_{41}NO_{10}$. On treatment with benzoic oxide, it forms derivatives containing four benzoyl groups for every C_{33} originally present; differing from aconitine, which gives only a di-benzoyl derivative. Japaconine gives the same derivative on benzoylation. These alkaloids closely resemble aconitine and aconine and are distinguished only by analysis or by their benzoyl derivatives. Japaconitine forms readily crystallizable salts especially with nitric, hydrochloric and hydrobromic acids, the latter salt containing 2½ H_2O for every C_{33}, like aconitine. (6) In isolating japaconitine, plain alcohol, instead of alcohol acidified with tartaric acid must be used. All the alkaloids are easily extracted thus. (7) The relation of japaconitine to its derivatives and to aconitine is conveniently expressed by regarding it as formed by the sesquihydration of an alkaloid $C_{33}H_{47}NO_{12}$ not yet isolated.—*J. Chem. Soc.*, xxxv, 387, July, 1879. G. F. B.

7. *Determination of Vapor Densities.*—The method of determining the density of vapors invented by Victor and Carl Meyer has already been noticed in this Journal, and the chief results which they have obtained by means of it have been stated. But this method demands more than a passing notice. It is so simple in its theory and manipulation, so universal in its application, and it avoids in such a remarkable way the main difficulties and sources of inaccuracy, which are inherent in all the methods hitherto employed for the same purpose, that it promises to become one of the most important aids in the investigation of chemical science. The theory of the method may be stated thus.

If a known amount of some volatile substance is suddenly dropped into an appropriate vessel heated to a constant temperature, which is sufficiently high to convert the material to an aeriform condition, it is obvious that the substance in volatilizing will expel from the vessel a quantity of air, which must be the exact equivalent of the volume of vapor formed—that is, an amount of air which at the unknown temperature and pressure in the vessel would just fill the space of the vapor. Hence then the specific gravity of the vapor is the known weight of the material used divided by the weight of the air expelled. The problem is thus reduced to finding the weight of the air expelled, and is wholly independent of the temperature or volume of the vessel, both of which may remain unknown quantities. All the uncertainties, therefore, connected with the measurements of high temperatures, or of the volume of the vessel under such conditions, are avoided. We have only to collect the air over a common water pneumatic trough and measure its volume, at the ordinary temperature and pressure of the air in the laboratory, and from these data we can easily calculate the weight required; or, if the material under examination is liable to oxidation, the vessel may be previously filled with nitrogen or some other inert gas, since the volume of such gas will be the same as the volume of the air under the same circumstances.

The only apparatus required in most cases is represented in the accompanying figure, which is drawn to scale. The bulb *b* has a capacity of about 100 $\overline{\text{c.m.}}^{3}$ and is about 20 c.m. long, and the glass tube to which it is attached is about 60 c.m. long and 6 mm. wide. The upper end of this tube is closed by a rubber stopper *d*, while to its side is united the very narrow delivery tube *a*, which conducts the expelled air to a pneumatic trough. By means of a wire guard the bulb is prevented from touching the sides of the iron bath in which it is heated, and a small amount of asbestos at the bottom of the bulb serves to break the fall of the small weighing tube, holding the weighed substance, which is dropped in at *d*. The iron bath is made of a short piece of two-inch gas pipe closed by welding at the bottom, and supported on a tripod of such height that, while the tripod stands on the floor, the pneumatic trough may stand on a table of medium height. In the bath may be used paraffine or a molten metal as circumstances require, and its temperature is maintained by gas burners, more or less powerful according to the temperature to be obtained. For comparatively low temperatures the most convenient bath is the vapor of some high boiling liquid, whose ebullition is so regulated that the vapor condenses before reaching the open mouth of the long necked boiling flask in which the bulb is held. In a bath of melted lead a low red heat is easily obtained, and it has been found that tubes of Bohemian glass will readily sustain this temperature without collapsing, for, although the glass may take a new set under the circumstances, the resulting change of volume is of no importance in this process. In their later experiments, the Brothers Meyer have used a porcelain vessel, heated in the muffle of a gas furnace to a temperature above the melting point of cast-iron.



After the bath has been heated to the degree required, and its temperature has become constant (a condition which is indicated by the fact that bubbles of gas cease to escape from the open mouth of the tube, while at the same time there is no tendency in the water to recede) the necessary observations are made in a very simple way. The stopper at *d* is removed, the small tube containing the weighed substance is dropped in, and the stopper instantly replaced. The few bubbles of air displaced by the stopper are of course neglected; but the air, which soon begins to stream over in consequence of volatilization of the material introduced, is collected over water in an ordinary graduated tube. The experiment is soon finished, and the stopper *d* must then be removed, to prevent any recession of the water in the trough.

It remains only to measure the volume of the air in the graduated tube with the usual precautions. For this purpose the tube with its contents is transferred to a tall cylindrical glass vessel of water, and held by a clamp in a vertical position, so that the water is at the same level within and without the tube, and, as soon as an equilibrium of temperature is attained, we observe the volume of the air, the temperature of the air (necessarily the same as that of the water confining it) and the height of a neighboring barometer. We have now V, H and *t*, from which we can calculate the corresponding weight. But in making this calculation we must remember that the air when measured is saturated with moisture, and therefore, that in order to find the true tension of the confined air, we must subtract from the *reduced height* of the barometer the maximum tension of the vapor of water at the temperature *t*. Representing by *h* this tension (which will be found in Regnault's tables), we have for the weight of the air displaced by the vapor

$$W' = 0{\cdot}001293\frac{H-h}{76}\cdot\frac{273}{273+t}V;$$

and if W represents the weight of the substance used

$$\text{Sp. Gr.} = \frac{W}{W'}.$$

For convenience of logarithmic calculation these formulæ are easily combined into the following form:

$$\log(\text{Sp. Gr.}) = 2{\cdot}3330 + \text{ar. co.}\log(H-h) + \log(273+t) + \text{ar. co.}\log V + \log W.$$

In these determinations it is important that the amount of substance taken should never more than one-half fill the vessel *b* with vapor, lest, in the process, some of the vapor should be driven out with the air. The least loss of material caused in this way would evidently be fatal to the accuracy of the method; but, short of such a result, no admixture of the vapor with the air in the vessel can affect the process; since, according to the well-known laws of Dalton, *the elastic force of a mixture of gas and vapor is equal to the sum of the tensions which each would have separately.* In the case of a heavy vapor, no considerable mixing with the air during the short time of the experiment was to be feared, but, when the vapor was lighter than air, such a rapid admixture as would lead to large loss—even when the volume of the vapor was small as compared with that of the vessel—might reasonably be expected. Hence it was with surprise that the method was found to be applicable to light, vapors as the following example shows, selected for this reason to illustrate the manner in which the calculations are best made.

Example.—Determination of the specific gravity of the vapor of water: The vessel was heated to a constant temperature in the vapors of xylol and a tube containing 0·0102 grams of water dropped in as described. The air expelled measured 14·6 c.m. at 16°·1, and the reduced height of the barometer in the room was 72·33 c.m. By the tables the maximum tension of the vapor of water at 16°·1 is 1·36 c.m. Hence

Constant log	2·3330
$H-h=70·97$ or. co. log	8·1490
$273+t=289·1$ log	2·4611
$V=14·6$ ar. co. log	8·3356
$W=0·0102$ log	7·0086
Sp. gr. 0·613	9·7873

Theory H_2O 0·623

Two other independent determinations of the same value gave 0·63 and 0·64 respectively.

On account of the great ease with which vapor densities can be determined by this process, we have reason to hope that it will serve to greatly multiply the fundamental data on which our knowledge of molecular weights is based. Already some remarkable results of this kind have been obtained. Thus the vapor densities of arsenious and antimonious oxide at the temperature of molten cast iron have been found to be 13·8 and 19·8 respectively (the mean in each case of two determinations), and these correspond to the symbols As_4O_6 and Sb_4O_6 instead of the received symbols As_2O_3 and Sb_2O_3. On the other hand cuprous chloride at the same high temperature gave a vapor density of 6·93, corresponding to Cu_2Cl_2, thus confirming the received opinion in regard to its constitution, which was previously based chiefly on theoretical considerations connected with the atomicity of its elements.

In the Berichte der Deutsch. Chem. Gessell. of July 28th, received since the above was in type, we have an account of a still more remarkable result which the Brothers Meyer have obtained with their method of determining vapor densities. Having in the first place established the fact that mercury and oxygen (by experiment), and nitrogen (by inference), retain their normal vapor or gas density and therefore their normal molecular structure even at the highest temperature of a gas furnace, about 1567° C., they next experimented on chlorine, by dropping a weighed amount of $PtCl_2$ into the heated porcelain vessel above described; and it appears from these experiments that at temperatures above 800° chlorine gas undergoes disassociation. Thus at about 620° the density found was 2·42, 2·46.

Theory for Cl_2 2.45

At about	808°	the density	found was	2·21	2·19
"	1028°	"	"	1·85	1·89
"	1242°	"	"	1·65	1·66
"	1392°	"	"	1·66	1·69
"	1567°	"	"	1·60	1·62

Theory for $\frac{2}{3}$ Cl_2 1·63

Hence between 1242° and 1567° the density of chlorine gas is constant at two-thirds of its normal value, and its molecular weight which is normally 71 becomes at temperatures above 1200°, equal to 47·3. In the present paper the Brothers Meyer offer no definite explanation of this most remarkable result, but they refer to the old theory which regarded chlorine as an oxide as furnishing a possible explanation of the anomaly and propose to attempt to separate by diffusion at 1567° the disassociated elements of chlorine if such exist. J. P. C., JR.

8. *Compressibility of gases at high pressures.*—Amagat continues his work upon this subject at St. Etienne in a shaft 380 meters deep. He proposes to study a series of gases and gives, as a preliminary result, his observations upon nitrogen, taking this gas for a basis on account of the facility with which it can be prepared in a comparatively pure state. The results are given in the following table. P represents the pressure in meters of quicksilver, P′ the atmospheric pressure, *v* the original volume, P*v* the product of the pressure and the volume.

P	P′	P*v*	$\frac{Pv}{P.v.}$
96·698	127·223	51594	----
128·296	168·684	52860	0·9760
158·563	208·622	54214	0·9516
190·855	251·127	55850	0·9238
221·103	290·924	57796	0·8927
252·353	332·039	59921	0·8613
283·710	373·302	62708	0·8297
327·388	430·773	65428	0·7885

The temperature was maintained nearly constant from 22·00 to 22·03°. At 430 atmospheres it was found that the gas volume was one-fourth smaller than it should be according to Marriotte's law.—*C. R.*, lxxxviii, 1879, p. 336; *Beiblatter Annalen der Physik*, No. 6, 1879, p. 414. J. T.

9. *Elements of Modern Chemistry;* by ADOLPHE WURTZ, Professor of Chemistry of the Faculty of Medicine of Paris, etc. Translated, with the Author's approval, by Wm. H. Green, M.D. 687 pp. 12mo, with 132 illustrations. Philadelphia, 1879. (Lippincott & Co.).—In a preface to this American edition of Professor Wurtz's Chemistry, the author states that his friend and former pupil, Dr. Green, presents in this translation "a faithful, or even improved, representation of the original work." The hand of a master is seen in this book, which is simple, direct, and symmetrical in its discussion of elementary facts and principles. The subject of Chemical Philosophy is naturally divided under two heads; so much as is essential to the study of the metalloids is compressed into less than fifty pages, at the commencement of the volume, while the theory of Atomicity, the Constitution of Salts and Classification of Metals are treated in about the same space before the metals. The general ideas upon the Constitution of Organic Compounds are compressed into about thirty pages preceding that subject. Many teachers and students will gladly adopt this book as a manual. Its order is logical and the main

facts of discovery are clearly stated, and, as far as possible, in historical order, with a severe exclusion of extraneous matters. Its usefulness would be increased by a synoptical table of contents and a fuller index of proper names and subjects: e. g., one looks in vain for such important words as molecule, atom, Ampère, Avogrado, volume, gas, and many other equally essential terms. A French work has rarely a good index; but an English translation need not repeat this fault. In these days, when gas has completely replaced the old-time charcoal furnaces as a source of heat in the laboratory, it looks strange to see these historic things reproduced from old cuts in the newest French book. B. S.

II. Geology and Mineralogy.

1. *Discovery of specimens of Maclurea magna, of the Chazy, in the Barnegat limestone, near Newburg, New York;* by R. P. Whitfield. (From a letter to J. D. Dana, dated American Museum of Natural History, Central Park, New York, July 30, 1879.)—Being on business at Newburg, New York, on July 19th last, I stopped for a few minutes, in passing a quarry of the Barnegat limestone, situated near the northwest base of Snake Hill on the "Little Pond Road" one and three quarter miles southwest of Newburg Ferry, where I obtained from the thin shaly layers of the limestone, remains of three specimens of *Maclurea magna* Les., one of which is sufficiently well preserved to be unmistakable.

This information may aid somewhat in determining the age of the Taconic schists which you have been so ably discussing, and also serve to confirm the statement made by you on page 382 of the May number of this Journal.

2. *On a recent Silent discharge of Kilauea;* by Dr. Titus Coan. (From a letter to J. D. Dana, dated Honolulu, Hawaii, June 20, 1879.)—You may have heard, ere this, that Kilauea has again disgorged a fiery flood, and retired within her subterranean chambers. A little over ten years had elapsed, during which time the repairs of the eruption of 1868 were going on, until the emptied "South Lake" was replenished, "heaped up and running over;" when, without premonition, an unknown subterranean passage was opened and the vast fiery basin was emptied, as in 1868.* But this disgorgement was hidden and peculiar. The lake of fusion, which had been raised, by its self-made surrounding wall, nearly to the height of the outer rim of the crater, quietly subsided several hundred feet, ceased its boiling and nearly extinguished its fires, leaving nothing but a vast smoking cauldron.

You may remember that after the grand eruption of 1868, I succeeded in scrambling down into the bottom of this evacuated pit, about 400 feet deep, and measuring across its bottom, a distance of one mile minus about 100 feet. This awful cauldron had only a few days before been filled to overflowing with boiling lava, raging, rolling in fiery waves from side to side of the glowing pit, dashing against its heated walls and throwing up its sheets and spouts of liquid fire 20, 40 and 50 feet into the air, while the surrounding deposits of solidified scoria formed a smoking mountain. Out of the northern and northwest sides of this accumulated mass of volcanic products streams of liquid lava burst from time to time, flowing down into the central region of the crater, and thus raising it, foot by foot, for months and years. Added to these subaerial outflows, there were oft-repeated, upward or vertical gushings of lava through seams and crevices; and thus, by these twofold actions, the great central depression, caused by the subsidence of a very large area of this part of the crater, was gradu ally filled up.

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* Mr. Coan does not mention the precise time of this eruption; but, from some statements in the Sandwich Island papers, it probably took place in April last. The "South Lake" referred to is in the bottom of Kilauea; and, though large, is small compared with the area of the bottom of the pit, the longest diameter of which is 3½ miles. J. D. D.

One feature of this last eruption of Kilauea is the fact that the great molten lake was drawn off subterraneously, giving no warning of its movements, and leaving no visible indication of its pathway, or of the place of its final deposit. Other eruptions have blazed their way upon the surface to the sea, or while on their subterranean way have rent the superincumbent beds, throwing out jets of steam or of sulphurous gases, with here and there small patches or broad areas of lava. But as yet no surface marks of this kind reveal the silent, solemn course of this burning river. One theory is that it flowed deep in subterranean fissures, and finally disembogued far out at sea. Our ocean was much disturbed during these days, and we had what might be called a tidal wave of moderate magnitude. For some time after this eruption, Kilauea lay with scarcely any visible fire, and only here and there puffs of white steam and jets of escaping gases. All visitors were for several weeks greatly disappointed, and some were inclined to think that the vivid descriptions of former visitors were fabulous; but later advices report the old goddess as arousing from her slumbers, stirring up the coals, lighting her lamps and sending out fiery glances from her red eye-balls. So the old process of replenishment has begun and after another decade another disgorgement may take place.

Mokuaweoweo, the summit crater, has been quiet for a long time. Moderate earthquakes occasionally admonish us that nothing earthly is stable; our aerial thunders have never been more sublime than during March, April and May.

3. *The recent Eruption of Etna.*—In regard to this eruption we have before us the report of Professor O. Silvestri of the University of Catania to the Italian Ministry, and also the report of G. H. Owen, U. S. Consul at Messina, to the Department of State. The former is a quarto pamphlet of nineteen pages, with an excellent topographical map of the region to the distance of about twenty kilometers from the summit in all directions. Upon this is charted not only the course and extent of the recent outflow of lava but those of previous eruptions also.

Silvestri regards the recent eruption as a sequel to that of August 29, 1874, when a rift opened upon the northeastern side of the mountain, along which a number of eruptive mouths were formed and from which lava was discharged. At that time however the activity continued for only a few hours, although the rift remained open for some days. In his notice of that eruption (Bulletino del Vulcanismo Anno I.) Silvestri predicted that at the next eruption this rift would prove the weakest point and would be the scene of the outbreak. This is exactly what has happened. This fissure of 1874 has become extended, reaching across the main crater in a north-northeast and south-southwest direction, to a length of ten kilometers. And from its extremities the lava has poured forth, beginning on the evening of May 26th. On the southwest it took the direction of the old lava flow toward the town of Adernó, but its course was arrested after flowing about two kilometers. From the northeastern extremity of the rift the flow extended in the direction of Mojo, continuing to advance until about June 6, when it had reached a distance of eleven kilometers from its source, and its front had stopped but a short distance from the river Alcantara. Further details of Professor Silvestri's report may be found by English readers in Nature, June 26, 1879.

A paper presented to the Paris Academy of Sciences by M. Fonquè, says that "on the north-north-east side there are ten distinct craters, two of which are enormous (200^m diameter, and 80^m depth)."

The report of U. S. Consul Owen to the State Department is dated Messina, June 20, and in it he says: "The eruption was preceded by a slight shock of earthquake that was felt throughout the island and at Reggio on the continent. Two new craters were opened, one near the summit on the south-southwest side of the mountain and the other on the north-northeast lower down the slope. The former ceased to erupt after a day and half, while the latter continued its eruption till the 11th inst. The discharges of lava, especially on the side last mentioned, were attended by great shaking and trembling of the soil and loud detonations that could be heard at a distance of twenty miles. At the same time the crater began to emit great clouds of dense black smoke, ashes and cinders, that fell on the surrounding country in a shower, and were carried by the strong sirocco blowing at the time even as far north as the province of Naples. In Messina the pavements and balconies were covered with this black dust, and during its fall, which was of ten hours duration, it was disagreeable to go out of doors with the eyes unprotected. The lava, contrary to general opinion, was not a stream of liquid fire, but rather resembled a moving mass of stones in a state of incandescence, for as each successive discharge would expel the matter in a half melted condition, it would accumulate at the mouth of the crater, where cooling, it would remain, until pressed forward by the discharges of new lava. The flow, if so it can be called, was very gradual. The stream of lava toward the northeast was 700 meters in width and the distance traversed about eleven kilometers.

"The damages caused by the eruption have been estimated at 1,000,000 of liras. The property damaged consisted of vineyards and nut groves. Fortunately no lives were lost or villages destroyed.

"On the 15th inst. strong shocks of earthquake were felt at Riposto. The ground opened and many houses were shaken down. On this occasion eight persons were killed and many wounded. It is believed that the earthquakes were caused by the undermining of the soil owing to the recent eruptions."

C. G. R.

4. *Former extension northward of the South American Continent.*—The following paragraphs close a paper by A. Agassiz, entitled, Dredging Operations of the U. S. Coast Survey Schooner "Blake," from December, 1878, to March 10, 1879, in a Letter from A. Agassiz to C. P. Patterson, Sup't Coast Survey. (Bull. Mus. Comp. Zool., Cambridge, Mass., vol. v, No. 14, June, 1879.) The paper is illustrated by a map of the Carribean Sea, supplied by the Superintendent of the Coast Survey, which is highly instructive.

One of the most interesting results reached by this year's cruise is the light thrown upon the former extension of the South American Continent, by the soundings taken while dredging, and those subsequently made in the passages between the islands by Commander Bartlett. These, together with the soundings already known, enable us to trace the outline of the old continent with tolerable accuracy, and thus obtain some intelligible, and at the same time trustworthy, explanation of the peculiar geographical distribution of the fauna and flora of the West India Islands. As is well known, Cuba, the Bahamas, Hayti and Porto Rico, instead of showing, as we might naturally assume from their present proximity to Florida, a decided affinity in their fauna and flora with that of the Southern United States, show, on the contrary, unmistakable association with that of Mexico, Honduras and Central America; the Caribbean Islands show in part the same relationship, though the affinity to the Venezuelan and Brazilian fauna and flora is much more marked.

In attempting to reconstruct, from the soundings, the state of things existing in a former period, we are at once struck by the fact that the Virgin Islands are the outcropping of an extensive bank. The greatest depth between these islands is less than 40 fathoms, this same depth being found on the bank to the east of Porto Rico, the 100-fathom line forming, in fact, the outline of a large island, which would include the whole of the Virgin Islands, the whole of Porto Rico, and extend some way into the Mona Passage. The 100-fathom line similarly forms a large plateau, uniting Anguilla, St. Martin and St. Bartholomew. It also unites Barbuda and Antigua, forms the Saba Bank, unites St. Eustatius, St. Christopher, Nevis and Redonda. It forms an elongated plateau, extending from Bequia to the southwest of Grenada, and runs more or less parallel to the South American coast from the Margarita Islands, leaving a comparatively narrow channel between it and the 100-fathom line south of Grenada, so as to enclose Trinidad and Tobago within its limits, and runs off to the southeast in a direction also about parallel to the shore line. At the western end of the Caribbean Sea, the 100-fathom line forms a gigantic bank off the Mosquito coast, extending over one-third the distance from the mainland to the island of Jamaica. The Rosalind and Pedro Banks, formed by the same line, and a few other smaller banks, denote the position of more or less important islands which must have once existed between the Mosquito coast and Jamaica. On examining the 500-fathom line, we thus find that Jamaica is only the northern spit of a gigantic promontory, which once extended toward Hayti from the mainland, reaching from Costa Rica to the northern part of the Mosquito coast, and leaving but a comparatively narrow passage between it and the 500-fathom line encircling Hayti, Porto Rico and the Virgin Islands, in one gigantic island. The passage between Cuba and Jamaica has a depth of 3,000 fathoms, and that between Hayti and Cuba is not less than 873 fathoms, the latter being probably an arm of the Atlantic. The 500-fathom line connects, as a gigantic island, the banks uniting Anguilla to St. Bartholomew, Saba Bank, the one connecting St. Eustatius to Nevis, Barbuda to Antigua, and from thence extends south so as to include Guadeloupe, Marie-Galante and Dominica. This 500-fathom line thus forms one gigantic island of the northern islands, extending from Saba Bank to Santa Cruz, and leaving but a narrow channel between it and the eastern end of the 500-fathom line running round Santa Cruz. As Santa Cruz is separated from St. Thomas by a channel of forty miles, with a maximum depth of over 2,400 fathoms, this plainly shows its connection with the northern islands of the Caribbean group, rather than with St. Thomas, as is also well shown by the geographical relations of its Mollusca. The 500-fathom line again unites, in one gigantic spit extending northerly from the mouth of the Orinoco, all the islands to the south of Martinique, leaving Barbadoes to the east, and a narrow passage between Martinique and the islands of Dominica and St. Lucia. At the time of this connection, therefore, the Caribbean Sea connected with the Atlantic only by a narrow passage of a few miles in width between St. Lucia and Martinique, and one somewhat wider and slightly deeper between Martinique and Dominica, another between Sombrero and the Virgin Islands, and a comparatively narrow passage between Jamaica and Hayti. The Caribbean Sea, therefore, must have been a gulf of the Pacific, or have connected with it through wide passages, of which we find the traces in the Tertiary and Cretaceous deposits of the Isthmus of Darien, of Panama and of Nicaragua. Central America and northern South America at that time must have been a series of large islands with passages between them from the Pacific into the Caribbean. It is further interesting to speculate what must have become of the great equatorial current, or rather of the current produced by the northeast trades. The water banking up against the two large islands, then forming the Caribbean Islands, must, of course, have been deflected north, have swept round the northern shores of the Virgin Islands, Porto Rico and Hayti, and poured into the western basin of the Caribbean Sea, through the passage between Hayti and Cuba. This water being forced into a sort of funnel, by the 500-fathom line forming the southern line of the Great Bahama Island, which connected nearly the whole of the Bahamas with Cuba and formed a barrier to the western flow of the equatorial current, this must, therefore, for the greater part, have been deflected north, and either swept in a northeasterly direction, as the Gulf Stream now does, or round the north end of the Bahamas, across Florida, which did not then exist, across the Gulf of Mexico, and into the Pacific over the Isthmus of Tehuantepec.

The soundings made by Commander Bartlett, after I left the "Blake," to determine the ridges uniting the various islands between Sombrero and Trinidad, show plainly that the cold water of the Caribbean can only come in through the passage between Sombrero and the Virgin Islands, which is about 1,100 fathoms, with a bottom temperature of 38°, while the 500-fathom line, as I have said, forms a gigantic island of all the islands to the south of Sombrero, including Dominica, with a narrow passage of 1,000 fathoms between it and Martinique; the 500-fathom line again uniting into one large spit, as a part of South America, all the islands to the south of it. Thus the bulk of the water forced into the Caribbean Sea has a comparatively high temperature,—an average, probably, of the temperature of the 300-fathom line. The cold water of the Atlantic is, however, again forced into the western basin of the Caribbean through the Windward Passage, and all this through the Yucatan Channel, between Cape San Antonio and the Yucatan Bank. It is, therefore, incredible that with this huge mass of water pouring into the Gulf of Mexico, there should be anything like a cold current forcing its way uphill into the Straits of Florida, as has been asserted on theoretical grounds. The channel at Gun Key can only discharge the surplus by having a great velocity.

Mr. Garman, who as usual accompanied me, remained in the West Indies, after we left the "Blake" at Barbadoes, for the purpose of making collections of Reptiles and Fishes, with a view of throwing additional light on the former connections of the islands, as I have here attempted to trace it. One of the most interesting of the Reptiles we collected is a gigantic land tortoise, found at Porto Rico, differing only in size from the land turtle still found on Trinidad and adjoining parts of South America. It is closely allied to the gigantic turtles of the Gallopagos, and to the fossil land turtles, of which fragments have been described by the late Professor Wyman. These were collected by Mr. A. Julien at Sombrero, in the phosphate beds of the island.

5. *Footprint in the Mesozoic rocks of New Jersey.*—Mr. J. C. RUSSELL has obtained at Boonton, New Jersey, a fine three-toed or Ornithoid track, in the Mesozoic rock of the region. It measures 6·2 inches in length, and 5·5 in width.

6. *Footprints from the Anthracite Coal Measures, of the Mahanoy Coal Field, at the Ellangowan Colliery.*—A slab, having upon

it ripple-marks and seven footprints, has been obtained at this locality by Mr. W. Lorenz. The tracks, according to Dr. Leidy, have a breadth of about an inch, widely divergent toes, and the four on the right occupy a line of six inches and are about an inch and a half apart from those on the left; they appear to be single, that is, not made by fore and hind feet together. Mr. Lorenz suggests for them the name *Anthracopus Ellangowensis.—Proc. Acad. N. Sci. Philad.*, 1879, 164.

7. *The Auriferous Gravels of the Sierra Nevada and California;* by J. D. Whitney (continued from page 147.)—The following are the more important facts with regard to the fossils of the auriferous gravels. The *plants* were submitted to Professor Lesquereux; and he has reported the absence of Coniferous remains, that the species of deciduous trees, seventeen of which are from the Table Mountain deposit, are different from those now existing in the region; and that the evidence favors the view that the beds are Pliocene, but related by some forms to the Miocene.

The *mammalian remains* have been determined by Dr. Leidy, and his results are published partly in vol. I of the California Reports, and the remainder in his works on the Extinct Mammalian Fauna of Dakota and Nebraska, 1869, and Contributions to the Extinct Vertebrate Fauna of the Western Territories, 1873. The species reported from the gravels underneath basalt, come from Douglass Flat, Chili Gulch, and the Tuolumne Table Mountain. At the first two of these places were found remains of *Rhinoceros hesperius* Leidy; at Douglass Flat, a tooth of *Elotherium superbum* L., "perhaps the same as *E. ingens* of the Mauvaises Terres of White River;" *Mastodon Americanus*, forty-eight feet beneath the surface at Douglass Flat and also at the Tuolumne Table Mountain; and a portion of a humerus of a small species of *Equus*, from a depth of 210 feet, at the Table Mountain. Besides these, the gravels elsewhere have afforded, at Murphy's Diggings, west of Douglass Flat, a tibia of *Canis latrans;* in Merced County, near the line of Mariposa, in volcanic ash, remains of an extinct lama, *Auchenia Californica* L., besides a metacarpal "probably of a deer, some bones of a small horse, perhaps a Hipparion; from Alameda County, *Auchenia hesterna* L.;" from the gravels near Sonora, two teeth of the living American Tapir; at different points, *Mastodon Americanus*, "up to an elevation little if at all exceeding 3,000 feet," with also *M. obscurus* L.; at several localities also, *Elephas Americanus*, one nearly perfect skeleton near the Fresno River; *Equus caballus*, *E. excelsus* L., *E. pacificus* L.

Stone implements (including tools, pestles, mortars, platters, spear and arrow heads, etc.), are reported, from the gravels at the following localities, and if some are doubtful, the number of places is so large that the fact of occurrence in the gravels cannot be reasonably questioned. In Mariposa County, at Horse Shoe Bend, on the Merced River, at Hornitos and five miles northeast, and near Princeton; in Merced County, near Snelling; in Stanislaus County, at Dry Creek; in Tuolumne County, at Table Mountain,

Kincaid Flat, Wood's Creek, Mormon Creek; in Amador County, near Jackson; in El Dorado County, at Shingle Springs, Diamond Springs near Placerville, Spanish Flat, Kelsey's Diggings, Dry Creek, Coloma, Georgetown, Brownsville; in Placer County, near Gold Hill, Forest Hill, Byrd's Valley, Missouri Tunnel; in Nevada County, at Grass Valley, Myer's Ravine, Brush Creek; in Butte County, at Cherokee; also in Siskiyou and Trinity Counties, localities not mentioned.

Human bones are reported from Tuolumne and Calaveras Counties. (1.) Under Table Mountain, Tuolumne County, a human jaw, obtained by Dr. Snell; same locality, in the Sonora tunnel, at a depth of 180 feet, a portion of a skull given to C. F. Winslow in 1857, by P. K. Hubbs, of Vallejo, California, the finder, and by the former noticed in the Proceedings of the Boston Society of Natural History, for October 7, 1857, the same locality affording also a Mastodon's tooth and a "large stone bead" of white marble. Mr. Winslow also says that Capt. D. B. Akey related to him a discovery of a complete human skeleton from a tunnel under Table Mountain, but stated that he did not remember the tunnel, and the fact has not been verified.

(2.) In Calaveras County, in February, 1866, in the claim of Messrs. Mattison & Co., on Bald Mountain, near Altaville and Angel's, beneath the lava, from a depth of 130 feet. This is the skull which came into Professor Whitney's hands through Dr. Jones, who received it from Mr. Mattison, and which has been described by Dr. Jeffries Wyman. The material in which it had been embedded was mixed tufa and gravel, and attached to it was a specimen of *Helix mormonum*, a species now living in Nevada. According to Mr. Mattison, the succession of beds passed through from above to that containing the skull, was black lava, 40 feet; next below, gravel 3, light lava 30, gravel 5, light lava 15, gravel 25, dark brown lava 9, gravel (that containing the skull) 5. This bed rested on red lava 4 feet and red gravel 17 feet. Professor Whitney brings forward the testimony of Mr. Scribner and also of Dr. Jones; and says, "We have the independent testimony of three witnesses, two of whom were previously known to the writer as men of intelligence and veracity, while in regard to the third there is no reason for doubting his truthfulness. Each one of these gentlemen testifies to some points in the chain of circumstantial evidence going to prove the genuineness of the find. No motive for deception on the part of Mr. Mattison can be discovered, while the appearance of the skull itself bears strong, though silent, testimony to the correctness of the story."

Dr. Wyman's report, as is now well known, stated that the "skull presents no signs of having belonged to an inferior race. In its breadth it agrees with the other crania from California, except those of the Diggers, but surpasses them in the other particulars in which comparisons have been made. This is especially apparent in the greater prominence of the forehead and the capacity of its chamber. In so far as it differs in dimensions from the other crania from California, it approaches the Esquimaux." The following are the comparisons above referred to by Dr. Wyman, the measurements being in millimeters:

	Breadth of Cranium.	Breadth of Frontal.*	Frontal Arch.	Length of Frontal.	Height of Cranium.	Zygomatic Diameter.
22 Esquimaux..............	134·5	94	296·5	126·6	135	137·6
5 from Alaska.............	133·5	92·8	285·5	121·8	129·5	132
11 from different parts of Cal.	150·5	93·5	260	117	120·8	134
3 Digger Indians	136·6	88·3	280	119	120·3	141·5
The Fossil skull..........	150	101	300	128	134†	145

Professor Whitney regards the gravels as Pre-Glacial, and Pliocene, on the basis of the evidence from the fossils found in them. The origin of the gravels remains to be discussed by him in the second part of the volume, which, according to a prefatory note, will be published in a few months.

8. *Bone Cave in Moravia.*—A large number of mammalian bones of the diluvian period have lately been obtained from the bone-cave of Vypustek, Moravia (Professor K. Th. Liebe, Proceed. Imp. Acad. Vienna, May 23, 1879), and sent to the Imperial Museum at Vienna. The comparison of these remains with those from the Thuringian caves is important, especially with those from the cave of Lindenthal near Gera, which led Liebe and Nehring to the interesting conclusion that all this region was an extensive barren steppe, without any forest vegetation, at the beginning of the Second Diluvial Period. In the cave of Vypustek are found—*Lynx vulgaris*, *Felis catus*, *Canis spelæus*, *C. familiaris*, *Vulpes vulgaris*, *V. lagopus*, *Gulo borealis*, *Martes abietinus*, *Fœtorius putorius*, *F. erminea*, *Vesperugo serotinus*, *Arvicola amphibius*, *A.* sp., *Lepus variabilis* (*timidus?*), *Cricetus frumentarius*, *Myoxus glis*, and *Sciurus vulgaris*. Besides these seventeen species, von Hochstetter found remains of *Elephas primigenius*, *Rhinoceros tichorhinus*, *Equus fossilis*, *Bos priscus*, *Cervus tarandus*, *C. elaphus*, *C. capreolus*, *C. euryceros* (*?*), *Capra ibex*, *Ursus spelæus*, *Felis spelæa*, and *Hyæna spelæa;* the number of species found in the Vypustek Cave being therefore twenty-nine. The evidence proves that this cave was a den of beasts of prey, long tenanted by families of hyenas and bears, and occasionally visited by lions, lynxes and wolves; while many side galleries, some opening to-day, gave shelter to martens, weasels and other small carnivores. Some few animals may have been carried into the cave after death by streams and floods; but by far the greater part of the remains are those of tenants of the cave, or of their prey brought in for food. The fauna of this cave indeed bears a decidedly sylvestran character; and it may be admitted that its environs were covered with woods, and had a forest climate, at

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* This is the breadth of the frontal at its narrowest part when the skull is viewed from above.

† Measured from the anterior edge of the foramen magnum to the level of the top of the frontal, and an inch behind it on the inside. (These measurements can, of course, be considered only as approximations; the fragmentary condition of the skull must be taken into consideration in this connection.)—J. W.

the time when northern and middle Germany had the features and climate of a steppe. Hence too the mountains and hills of South Bohemia and Moravia may be supposed to have been the center from which forests advanced gradually in every direction over the great Diluvial Steppe of Europe north of the Alpine chain. Further explorations, to be conducted by the Prehistoric Commission of the Imperial Academy of Vienna, may lead to other interesting facts as to the relative depth and succession of the animal remains in this cave.—*Nature*, July 24.

9. *Geology of Kansas;* by Professor B. F. MUDGE.—The Report of the State Board of Agriculture of Kansas, for the years 1877–8 (a volume of 632 pages, 8vo, second edition, published at Topeka, Kansas, in 1878), contains a report on the geology of the State, by Professor Mudge. It is a valuable account by one who has done much to bring the facts to light, and is accompanied by a colored geological map. The geological formations include the Drift (some of whose bowlders are of large size), Tertiary beds, Cretaceous of the Niobrara, Benton and Dakota divisions, and the Carboniferous, Sub-carboniferous and Permian. Professor Mudge collected a large part of the fossil plants from the Dakota group which have been described by Lesquereux, and also numerous new fossils among fishes and other vertebrates. The report treats also of the economical geology of the state, its gypsum, salt, lead and zinc ores, and coal.

The Agricultural Report is also in other respects a well digested and instructive volume.

10. *Geological Report of Indiana for* 1878*;* by E. T. Cox, assisted by Professor J. COLLETT and Dr. G. M. LEVETTE.—This new volume contains special reports on the geology of Wayne County, Harrison County, and Crawford County, besides a general Report by Professor Cox, the Report on the geological nomenclature of the Cincinnati rocks, already noticed in this Journal, a list of fossils of the rocks of the Trenton period in adjoining parts of Indiana, Ohio and Kentucky, by S. A. Miller, on Hydraulic Cements, Glacial Drift, Archæology, with a list of the Ferns, Mosses, Hepaticæ and Lichens of Wayne County, by Mrs. Haines.

11. *Genera of Felidæ and Canidæ.*—A paper on the genera of these families with important notes on some species relating principally to the fossil species, is published by Professor E. D. Cope, in the Proceedings of the Academy of Natural Sciences of Philadelphia, for 1879, commencing on page 168.

12. *The Mosasaur,* Leiodon anceps, *of the American Cretaceous.*—Professor R. Owen has a paper on the "Restoration of *Leiodon anceps*" in the Annals and Magazine of Natural History, July, 1879.

III. BOTANY.

1. *On the Origin of the Flora of the European Alps;* by JOHN BALL, F.R.S.—A lecture delivered at a meeting of the Royal Geographical Society, London, June 9, printed in its Proceedings, and separately issued as a pamphlet of 25 pages. No

one knows more than Mr. Ball of the Alpine flora, and in this lecture he discourses interestingly and very boldly upon the theoretical bearings of this extensive knowledge. His points are, that the Alpine flora did not originate in Scandinavia, but came rather from Northern Asia; that we must consider even the existing species to be very much older than the glacial period, in order to account for the actual distribution; that, since it is clear that the upper limit of Alpine vegetation is not assigned by temperature but by lack of room (upon a single ridge rising out of the Aletsch glacier, at 10,700 feet, he collected at one visit over forty flowering species), so he contends that it could not have been driven out of the Alps even by the maximum cold of the glacial period, which he supposes to have lowered the zones of vegetation only one or two thousand feet. All this will accord very well with the views taken by Saporta and not a few other naturalists. But, if we rightly understand, Mr. Ball goes on to assign an enormous antiquity—such as no one has thought of—to the existing types of phænogamous plants and to the temperate and arctic-Alpine vegetation. He supposes these to have flourished at great elevations on Paleozoic Alps at the time when the Carboniferous vegetation covered the low levels, and while the atmosphere contained twenty times as much carbonic acid as now, this gas, as he calculates, being stratified in the atmosphere according to its density, in such manner as to give to paleo-alpine plants an atmosphere and a climate not very unlike the present. He asks us to believe with him that "those humble plants that dwell in the highest region of lofty mountains, springing from crevices in the rock, or fringing with bright color the edges of the snow-field," "exempted from the vicissitudes to which the ancient vegetable world was exposed, may represent the earliest forms of the higher types of plant-life, and even that some of the species that now adorn the Alpine heights may, during the inconceivably long lapse of geological ages, have looked down unchanged on the revolutions that have slowly destroyed and renewed the various forms of life on the surface of our planet." A. G.

2. *The Native Plants of Victoria succinctly defined;* by Baron Ferd. von Mueller, F.R.S., etc. Part I, pp. 190, 8vo. Melbourne, 1879.—No sooner is the great *Flora Australiensis* completed, than the indefatigable Mueller sets himself to the preparation of an easy manual for the most populous colony of Victoria, and this is the first installment. It begins with the Polypetalous (Choripetalous) orders, intercalating the apetalous ones in a manner now not uncommon; it illustrates them by good wood-cut figures, with clear analyses, describes them in the simplest possible technical language, omits synonymy and also references, except those for the origination of the genus and species; and in short supplies just what is needed for educational and popular use. Let us hope that the worthy author will be encouraged and enabled to complete it. A novel peculiarity of this work is that the introduced plants are rigidly left out, even those which are overpowering the

native species. These weeds are a nuisance in every sense, to the botanist no less than to the colonist, and glad should we be everywhere to ignore them if we could. But, as a classical English poetess sings of

> "Tall Buttercups that will be seen
> Whether we will or no,"

the botanist cannot well shut his eyes to the intruders, although they do spoil the symmetry and purity of a flora. A. G.

3. *The Influence of Light on the Motions of Desmids;* by E. STAHL.—The fact that Desmids, under the influence of light, possess certain peculiar motions, was first noticed by Alexander Braun. Stahl has experimented upon species of *Closterium*, and finds that the individual *Closteria* have their longer axis parallel to the direction of the light. If placed in a glass cell, the end of the *Closterium* which is from the light attaches itself to the bottom of the cell, while the other floats freely and follows the direction of the light if it is changed. The *Closteria* undergo periodical changes of position; the floating free end toward the light finally moving backward and attaching itself to the bottom, while the end which was at first fixed becomes free. At the end of the paper, Stahl has some remarks on photometric and aphotometric swarm-spores. In a recent paper Strasburger gives the name of phototaxis to the property which swarm-spores possess of placing their long axes parallel to the direction of the light. He divides phototactic swarm-spores into photometric and aphotometric. In the latter class are included those swarm-spores which have their ciliated extremity turned toward the light. Photometric swarm-spores are those which may present either extremity toward the light. To the latter class, according to Strasburger, belong the swarm-spores of *Botrydium*. Stahl, however, maintains that the spores of *Botrydium* act like other swarm-spores, and he doubts the validity of the two forms of phototaxis as described by Strasburger. W. G. F.

4. *Development of the Prothallus of Platycerium grande;* by Dr. HERMANN BAUKE.—In a paper read before the Bot. Verein of the Provinz Brandenburg, Dr. Bauke showed that the early stages of the prothallus of *Platycerium grande* differed from that of other ferns. The growth of the terminal cell of the germinal filament which comes from the spore ceases at an early period, and the cells back of it grow so as to form a peculiar membrane. From one side of this membrane shoots out a process which bears the sexual organs. In this method of growth, Dr. Bauke sees a special adaptation for the exposed place of attachment of this species, which is found very frequently on palm stems just before the terminal tuft of leaves. Dr. Bauke also discusses the dependence of the bilateral character of the fern prothallus on external forces, and assigns to gravity the principal action. In prothalli which grow vertically archegonia and rhizoids are found on both surfaces. W. G. F.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Map of the Catskill Mountains*, by A. GUYOT.—Professor Guyot gives in this map the results of several summers' work in the Catskill region with his barometer and surveying instruments. He has measured the height of over two hundred places, determined by triangulation the positions of all the many summits, and discovered mountains that were not known to exist. A large part of the region, especially the southwestern, is an untracked wilderness of forests; and in several cases the only chance for making his triangulation was by climbing to the tops of the highest trees. He has found higher points than were before recorded, and many of them. His table of altitudes contains three peaks over 4,000 feet, thirteen over 3,800 feet, and thirty-six over 3,500 feet. The highest point is one of the previously unknown, Slide Mountain, in the Southern Catskills; its height is 4,205 feet above tide. An abstract of his results will appear in another number of this Journal.

The map measures 14 × 20 inches, is complete in all the topography and in geographical details, and will be of great service to tourists. It may be had in New York of Scribner's Sons and B. Westerman & Co.

2. *J. L. Campbell's "Geology of Virginia," page* 119 *of this volume.*—The following explanations of the section on page 121 were omitted in their proper places and are here inserted:—1. General bearing of the section N. 40° W. 2. Horizontal scale in miles numbered at top; vertical scale in feet numbered on right and left extremities. 3. Limestone strata are *blocked*, sandstones *dotted*, and shales *ruled*. 4. The periods and epochs are indicated, the former by *numbers*, the latter by *letters*, in accordance with the system found in Professor Dana's Manual of Geology.

3. *To Astronomers.*—The U. S. Naval Observatory, Washington, will gratefully receive for its library, *separate copies* or *reprints* of memoirs published in the Transactions of Societies or in journals. The volumes of Transactions are regularly received, but often many months after the appearance of the reprints of particular papers, which are therefore especially valued. It is also requested that all communications of this nature and correspondence relating to them may be addressed to "The Library, U. S. Naval Observatory, Washington, U. S. A."

Agents of the Smithsonian Institution abroad will receive large parcels for transmission. The smaller ones will be received more quickly if they are sent by mail.

As far as possible, the publications of the Observatory will be distributed to all working astronomers.

JOHN RODGERS, Rear Admiral, U. S. N., Superintendent.

Washington, Aug. 18, 1879.

4. *Annual Report upon Explorations and Surveys in the Department of the Missouri;* by E. H. RUFFNER, First Lieut. Eng. U. S. A.—This Report is Appendix SS (pp. 1749–1868) of the Annual Report of the Chief of Engineers for 1878. It contains a *Report on the San Juan region*, in Western Colorado and part of New Mexico, from a reconnoissance made in 1877, by Lieut. C.

A. H. McCauley, accompanied by maps and sketches. Lieut. McCauley gives an extended account of the geography, features, the various mines, agricultural and other economical resources, with some observations on the geology, the erosion and terraces along the rivers, and details as to settlements, means of communication, and proposed new lines of roads and railroads. The report is evidently the result of a careful study of the region. It also contains a classification of the Botanical Collection made by the same expedition, by Professor Asa Gray, with Notes on the Botany, by T. S. Brandegee; and an Entomological report by Professor Cyrus Thomas, which is illustrated by two plates of butterflies.

5. *Documents relative to the Origin and History of the Smithsonian Institution;* edited by Wm. J. Reeves. 1013 pp. 8vo. Washington, 1879. Smithsonian Miscellaneous Collections, 328. —The will of James Smithson, and all papers connected with his gift for the establishment of a "Smithsonian Institution" at Washington, are brought together in this volume, and also the communications which have since been made by or to the United States Government, the debates and acts relative to it, the programme of Professor Henry, and the correspondence with reference to it. The value of the Institution to the country makes everything pertaining to its history of the highest interest.

6. *On the Mode of Growth of Stromatopora;* by H. J. Carter, F.R.S., etc.—Struck with the practical nature of Mr. Champernowne's remarks on "some Devonian Stromatoporidæ from Dartington, near Totnes," published in the Quart. Journ. Geol. Soc. for February, 1879, I lost no time in putting myself in communication with him on this subject, and, having received, in reply, a kind invitation to visit the "Pit-Park Quarry" (whence his specimens had been taken), I availed myself of the opportunity on the 8th of May last.

My general inference from our visit to the Quarry was that *Stromatopora* was essentially a "reef building" organism, and that, like *Millepora alcicornis* in the West Indies, it grew profusely in its locality, not only entering and filling up the open interstices of other calcareous organisms during their growth, but enveloping their detritus (joints and stems of Encrinites, etc.), and, when not doing either of these things, growing into large masses of itself. Thus, by cementing everything together after this manner, the great reef appears to have been formed which is now known by the name of "Devonian Limestone." This is not only evidenced by the composition of the *solidified* strata generally, when cut and polished, but more convincingly and particularly by a portion of it in "Pit-Park Quarry," which, having undergone partial decomposition, now yields up its contents even more separately than probably they have ever been since they were bound together by the ubiquitous *Stromatopora.—From a paper in the Ann. and Mag. Nat. Hist. for August.*

7. *Möbius on Eozoon Canadense.*—A full abstract of Professor Möbius's paper on Eozoon, with illustrations copied from it, is contained in *Nature* for July 17, and 24.

Report of the Chief of Engineers for 1878. Three volumes, 8vo. Washington, 1878.

THE

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JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XXXV.—*On Radiant Matter: A Lecture delivered to the British Association for the Advancement of Science, at Sheffield, Friday, August* 22, 1879; by WILLIAM CROOKES, F.R.S.

To throw light on the title of this lecture I must go back more than sixty years—to 1816. Faraday, then a mere student and ardent experimentalist, was 24 years old, and at this early period of his career he delivered a series of lectures on the General Properties of Matter, and one of them bore the remarkable title, *On Radiant Matter*. The great philosopher's notes of this lecture are to be found in Dr. Bence Jones's "Life and Letters of Faraday," and I will here quote a passage in which he first employs the expression *Radiant Matter*:—

> "If we conceive a change as far beyond vaporization as that is above fluidity, and then take into account also the proportional increased extent of alteration as the changes rise, we shall perhaps, if we can form any conception at all, not fall far short of Radiant Matter; and as in the last conversion many qualities were lost, so here also many more would disappear."

Faraday was evidently engrossed with this far-reaching speculation, for three years later—in 1819—we find him bringing fresh evidence and argument to strengthen his startling hypothesis. His notes are now more extended, and they show that in the intervening three years he had thought much and deeply on this higher form of matter. He first points out that matter may be classed into four states—solid, liquid, gaseous and radiant—these modifications depending upon differences in their several essential properties. He admits that the existence of Radiant Matter is as yet unproved, and then proceeds, in a series of ingenious analogical arguments, to show the probability of its existence.*

If, in the beginning of this century, we had asked, What is a Gas? the answer then would have been that it is matter, expanded and rarefied to such an extent as to be impalpable, save when set in violent motion; invisible, incapable of assuming or of being reduced into any definite form like solids, or of forming drops like liquids; always ready to expand where no resistance is offered, and to contract on being subjected to pressure. Sixty years ago such were the chief attributes assigned to gases. Modern research, however, has greatly enlarged and modified our views on the constitution of these elastic fluids. Gases are now considered to be composed of an almost infinite number of small particles or molecules, which are constantly moving in every direction with velocities of all conceivable magnitudes. As these molecules are exceedingly numerous, it follows that no molecule can move far in any direction without coming in contact with some other molecule. But if we exhaust the air or gas contained in a closed vessel, the number of molecules becomes diminished, and the distance through which any one of them can move without coming in contact with another is increased, the length of the mean free path being inversely proportional to the number of molecules present. The further this process is carried the longer becomes the average distance a molecule can travel before entering into collision; or, in other words, the longer its mean free path, the more the physical properties of the gas or air are modified. Thus, at a certain point, the phenomena of the radiometer become possible, and on pushing the rarefaction still further, i. e., decreasing the number of molecules in a given space and lengthening their mean free path, the experimental results are obtainable to which I am now about to call your attention. So distinct are these phenomena from anything which occurs in air or gas at the ordinary tension, that we are led to assume that we are here brought face to face with Matter in a Fourth state or condition, a condition as far removed from the state of gas as a gas is from a liquid.

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* "I may now notice a curious progression in physical properties accompanying changes of form, and which is perhaps sufficient to induce, in the inventive and sanguine philosopher, a considerable degree of belief in the association of the radiant form with the others in the set of changes I have mentioned.

"As we ascend from the solid to the fluid and gaseous states, physical properties diminish in number and variety, each state losing some of those which belonged to the preceding state. When solids are converted into fluids, all the varieties of hardness and softness are necessarily lost. Crystalline and other shapes are destroyed. Opacity and color frequently give way to a colorless transparency, and a general mobility of particles is conferred.

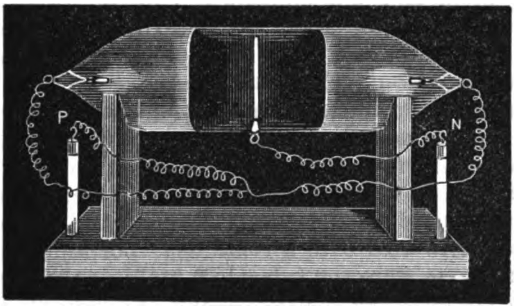
"Passing onward to the gaseous state, still more of the evident characters of bodies are annihilated. The immense differences in their weight almost disappear; the remains of difference in color that were left, are lost. Transparency becomes universal, and they are all elastic. They now form but one set of substances, and the varieties of density, hardness, opacity, color, elasticity and form, which render the number of solids and fluids almost infinite, are now supplied by a few slight variations in weight, and some unimportant shades of color.

"To those, therefore, who admit the radiant form of matter, no difficulty exists in the simplicity of the properties it possesses, but rather an argument in their favor. These persons show you a gradual resignation of properties in the matter we can appreciate as the matter ascends in the scale of forms, and they would be surprised if that effect were to cease at the gaseous state. They point out the greater exertions which Nature makes at each step of the change, and think that, consistently, it ought to be greatest in the passage from the gaseous to the radiant form."—*Life and Letters of Faraday*, vol. i, p. 308.

Mean Free Path. Radiant Matter.

I have long believed that a well-known appearance observed in vacuum tubes is closely related to the phenomena of the mean free path of the molecules. When the negative pole is examined while the discharge from an induction-coil is passing through an exhausted tube, a dark space is seen to surround it. This dark space is found to increase and diminish as the vacuum is varied, in the same way that the mean free path of the molecules lengthens and contracts. As the one is perceived by the mind's eye to get greater, so the other is seen by the bodily eye to increase in size; and if the vacuum is insufficient to permit much play of the molecules before they enter into collision, the passage of electricity shows that the "dark space" has shrunk to small dimensions. We naturally infer that the dark space is the mean free path of the molecules of the residual gas, an inference confirmed by experiment.

1.



I will endeavor to render this "dark space" visible to all present. Here is a tube (fig. 1), having a pole in the center in the form of a metal disk, and other poles at each end. The center pole is made negative, and the two end poles connected together are made the positive terminal. The dark space will be in the center. When the exhaustion is not very great the dark space extends only a little on each side of the negative pole in the center. When the exhaustion is good, as in the tube before you, and I turn on the coil, the dark space is seen to extend for about an inch on each side of the pole.

Here, then, we see the induction spark actually illuminating the lines of molecular pressure caused by the excitement of the negative pole. The thickness of this dark space is the measure of the mean free path between successive collisions of the molecules of the residual gas. The extra velocity with which the negatively electrified molecules rebound from the excited pole keeps back the more slowly moving molecules which are advancing toward that pole. A conflict occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the discharge.

Therefore the residual gas—or, as I prefer to call it, the gaseous residue—within the dark space is in an entirely different state to that of the residual gas in vessels at a lower degree of exhaustion. To quote the words of our last year's President, in his Address at Dublin:—

> "In the exhausted column we have a vehicle for electricity not constant like an ordinary conductor, but itself modified by the passage of the discharge, and perhaps subject to laws differing materially from those which it obeys at atmospheric pressure."

In the vessels with the lower degree of exhaustion, the length of the mean free path of the molecules is exceedingly small as compared with the dimensions of the bulb, and the properties belonging to the ordinary gaseous state of matter, depending upon constant collisions, can be observed. But in the phenomena now about to be examined, so high is the exhaustion carried that the dark space around the negative pole has widened out till it entirely fills the tube. By great rarefaction the mean free path has become so long that the hits in a given time in comparison to the misses may be disregarded and the average molecule is now allowed to obey its own motions or laws without interference. The mean free path, in fact, is comparable to the dimensions of the vessel, and we have no longer to deal with a *continuous* portion of matter, as would be the case were the tubes less highly exhausted, but we must here contemplate the molecules *individually*. In these highly exhausted vessels the molecules of the gaseous residue are able to dart across the tube with comparatively few collisions, and radiating from the pole with enormous velocity, they assume properties so novel and so characteristic as to entirely justify the application of the term borrowed from Faraday, that of *Radiant Matter*.

Radiant Matter exerts powerful phosphorogenic action where it strikes.

I have mentioned that the Radiant Matter within the dark space excites luminosity where its velocity is arrested by residual gas outside the dark space. But if no residual gas is left, the molecules will have their velocity arrested by the sides of the glass; and here we come to the first and one of the most noteworthy properties of Radiant Matter discharged from the negative pole—its power of exciting phosphorescence when it strikes against solid matter. The number of bodies which respond luminously to this molecular bombardment is very great, and the resulting colors are of every variety. Glass, for instance, is highly phosphorescent when exposed to a stream of Radiant Matter. Here (fig. 2) are three bulbs composed of different glass: one is uranium glass (*a*), which phosphoresces of a dark green color; another is English glass (*b*), which phosphoresces of a blue color; and the third (*c*) is soft German glass,—of which most of the apparatus before you is made,—which phosphoresces of a bright apple-green.

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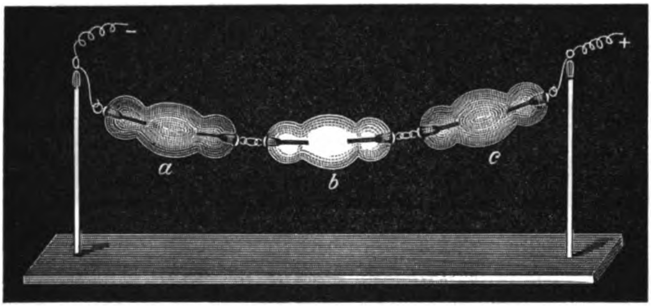

My earlier experiments were almost entirely carried on by the aid of the phosphorescence which glass takes up when it is under the influence of the radiant discharge; but many other substances possess this phosphorescent power in a still higher degree than glass. For instance, here is some of the luminous sulphide of calcium prepared according to M. Ed. Becquerel's description. When the sulphide is exposed to light—even candlelight—it phosphoresces for hours with a bluish white color. It is, however, much more strongly phosphorescent to the molecular discharge in a good vacuum, as you will see when I pass the discharge through this tube.

Other substances besides English, German, and uranium glass, and Becquerel's luminous sulphides, are also phosphorescent. The rare mineral phenacite (aluminate of glucinum) phosphoresces blue; the mineral spodumene (a silicate of aluminium and lithium) phosphoresces a rich golden yellow; the emerald gives out a crimson light. But without exception, the diamond is the most sensitive substance I have yet met for ready and brilliant phosphorescence. Here is a very curious fluorescent diamond, green by daylight, colorless by candlelight. It is mounted in the center of an exhausted bulb (fig. 3), and the molecular discharge will be directed on it from below upward. On darkening the room you see the diamond shines with as much light as a candle, phosphorescing of a bright green.

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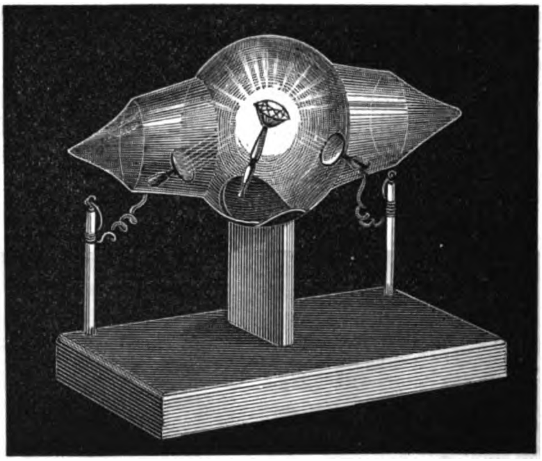

Next to the diamond the ruby is one of the most remarkable stones for phosphorescing. In this tube is a fine collection of ruby pebbles. As soon as the induction spark is turned on you will see these rubies shining with a brilliant rich red tone, as if they were glowing hot. It scarcely matters what color the ruby is, to begin with. In this tube of natural rubies there are stones of all colors—the deep red and also the pale pink ruby. There are some so pale as to be almost colorless, and some of the highly-prized tint of pigeon's blood; but under the impact of Radiant Matter they all phosphoresce with about the same color.

Now the ruby is nothing but crystallized alumina with a little coloring matter. In a paper by Ed. Becquerel,* published twenty years ago, he describes the appearance of alumina as glowing with a rich red color in the phosphoroscope. Here is some precipitated alumina prepared in the most careful manner. It has been heated to whiteness, and you see it also glows under the molecular discharge with the same rich red color.

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* Annales de Chimie et de Physique, 3rd series, vol. lvii, p. 50, 1859.

The spectrum of the red light emitted by these varieties of alumina is the same as described Becquerel twenty years ago. There is one intense red line, a little below the fixed line B in the spectrum, having a wave-length of about 6895. There is a continuous spectrum beginning at about B, and a few fainter lines beyond it, but they are so faint in comparison with this red line that they may be neglected. This line is easily seen by examining with a small pocket spectroscope the light reflected from a good ruby.

There is one particular degree of exhaustion more favorable than any other for the development of the properties of Radiant Matter which are now under examination. Roughly speaking it may be put at the millionth of an atmosphere.[*] At this degree of exhaustion the phosphorescence is very strong, and after that it begins to diminish until the spark refuses to pass.[†]

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[*] 1·0 millionth of an atmosphere = 0·00076 millim.
1315·789 millionths of an atmosphere = 1·0 millim.
1,000,000· " " " = 760·0 millims.
" " " " = 1 atmosphere.

[†] Nearly 100 years ago Mr. Wm. Morgan communicated to the Royal Society a Paper entitled "Electrical Experiments made to ascertain the Non-conducting Power of a Perfect Vacuum, &c." The following extracts from this Paper, which was published in the Phil. Trans. for 1785 (vol. lxxv, p. 272), will be read with interest:—

"A mercurial gage about fifteen inches long, carefully and accurately boiled till every particle of air was expelled from the inside, was coated with tin-foil five inches down from its sealed end, and being inverted into mercury through a perforation in the brass cap which covered the mouth of the cistern; the whole was cemented together, and the air was exhausted from the inside of the cistern through a valve in the brass cap, which producing a perfect vacuum in the gage formed an instrument peculiarly well adapted for experiments of this kind. Things being thus adjusted (a small wire having been previously fixed on the inside of the cistern to form a communication between the brass cap and the mercury, into which the gage was inverted) the coated end was applied to the conductor of an electrical machine, and notwithstanding every effort, neither the smallest ray of light, nor the slightest charge, could ever be procured in this exhausted gage."

"If the mercury in the gage be imperfectly boiled, the experiment will not succeed; but the color of the electric light, which in air rarefied by an exhauster is always violet or purple, appears in this case of a beautiful green, and, what is very curious, the degree of the air's rarefaction may be nearly determined by this means; for I have known instances, during the course of these experiments, where a small particle of air having found its way into the tube, the electric light became visible, and as usual of a green color; but the charge being often repeated, the gage has at length cracked at its sealed end, and in consequence the external air, by being admitted into the inside, has gradually pro-

I have here a tube (fig. 4) which will serve to illustrate the dependence of the phosphorescence of the glass on the degree of exhaustion. The two poles are at *a* and *b*, and at the end (*c*) is a small supplementary tube connected with the other by a narrow aperture, and containing solid caustic potash. The tube has been exhausted to a very high point, and the potash heated so as to drive off moisture and injure the vacuum. Exhaustion has then been re-commenced, and the alternate heating and exhaustion repeated until the tube has been brought to the state in which it now appears before you. When the induction spark is first turned on nothing is visible—the vacuum is so high that the tube is non-conducting. I now warm the potash slightly and liberate a trace of aqueous vapor. Instantly conduction commences, and the green phosphorescence flashes out along the length of the tube. I continue the heat, so as to drive off more gas from the potash. The green gets fainter, and now a wave of cloudy luminosity sweeps over the tube, and stratifications appear, which rapidly get narrower, until the spark passes along the tube in the form of a narrow purple line. I take the lamp away, and allow the potash to cool; as it cools, the aqueous vapor, which the heat had driven off, is re-absorbed. The purple line broadens out, and breaks up into fine stratifications; these get wider, and travel toward the potash tube. Now a wave of green light appears on the glass at the other end, sweeping on and driving the last pale stratification into the potash; and now the tube glows over its whole length with the green phosphorescence. I might keep it before you, and show the green growing fainter and the vacuum becoming non-conducting; but I should detain you too long, as time is required for the

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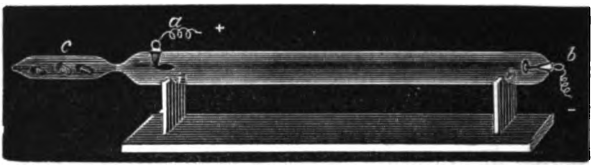

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duced a change in the electric light from green to blue, from blue to indigo, and so on to violet and purple, till the medium has at length become so dense as no longer to be a conductor of electricity. I think there can be little doubt, from the above experiments, of the non-conducting power of a perfect vacuum."

"This seems to prove that there is a limit even in the rarefaction of air, which sets bounds to its conducting power; or, in other words, that the particles of air may be so far separated from each other as no longer to be able to transmit the electric fluid; that if they are brought within a certain distance of each other, their conducting power begins, and continually increases till their approach also arrives at its limit."

absorption of the last traces of vapor by the potash, and I must pass on to the next subject.

Radiant Matter proceeds in straight lines.

The Radiant Matter, whose impact on the glass causes an evolution of light, absolutely refuses to turn a corner. Here is a V-shaped tube, a pole being at each extremity. The pole at the right side being negative, you see that the whole of the right arm is flooded with green light, but at the bottom it stops sharply and will not turn the corner to get into the left side. When I reverse the current and make the left pole negative, the green changes to the left side, always following the negative pole and leaving the positive side with scarcely any luminosity.

In the ordinary phenomena exhibited by vacuum tubes—phenomena with which we are all familiar—it is customary, in order to bring out the striking contrasts of color, to bend the tubes into very elaborate designs. The luminosity caused by the phosphorescence of the residual gas follows all the convolutions into which skillful glass-blowers can manage to twist the glass. The negative pole being at one end and the positive pole at the other, the luminous phenomena seem to depend more on the positive than on the negative at the ordinary exhaustion hitherto used to get the best phenomena of vacuum tubes. But at a very high exhaustion the phenomena noticed in ordinary vacuum tubes when the induction spark passes through them—an appearance of cloudy luminosity and of stratifications—disappear entirely. No cloud or fog whatever is seen in the body of the tube, and with such a vacuum as I am working with in these experiments, the only light observed is that from the phosphorescent surface of the glass. I have here two bulbs (fig. 5), alike in shape and position of poles, the only difference being that one is at an exhaustion equal to a few millimeters of mercury—such a moderate exhaustion as will give the ordinary luminous phenomena—while the other is exhausted to about the millionth of an atmosphere. I will first connect the moderately exhausted bulb (A) with the induction-coil, and retaining the pole at one side (*a*) always negative, I will put the positive wire successively to the other poles with which the bulb is furnished. You see that as I change the position of the positive pole, the line of violet light joining the two poles changes, the electric current always choosing the shortest path between the two poles, and moving about the bulb as I alter the position of the wires.

This, then, is the kind of phenomenon we get in ordinary exhaustions. I will now try the same experiment with a bulb (B) that is very highly exhausted, and as before, will make the side pole (a') the negative, the top pole (b) being positive. Notice how widely different is the appearance from that shown by the last bulb. The negative pole is in the form of a shallow cup. The molecular rays from the cup cross in the center

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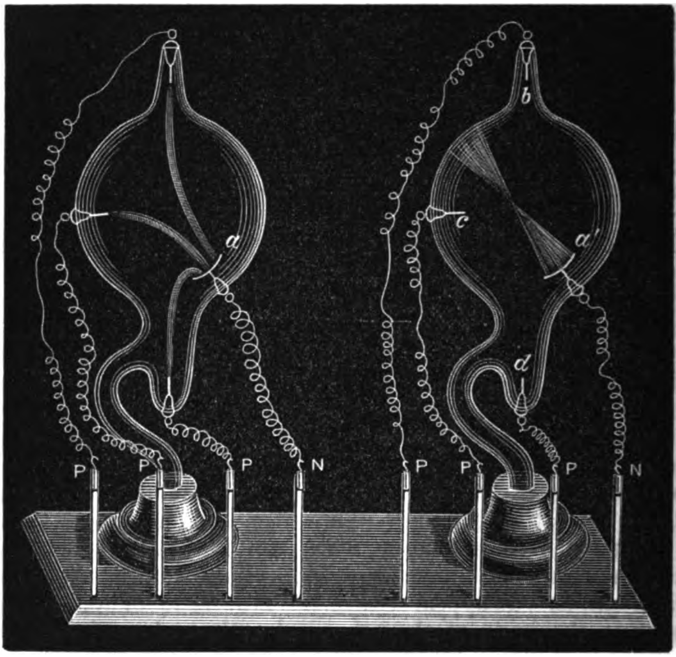
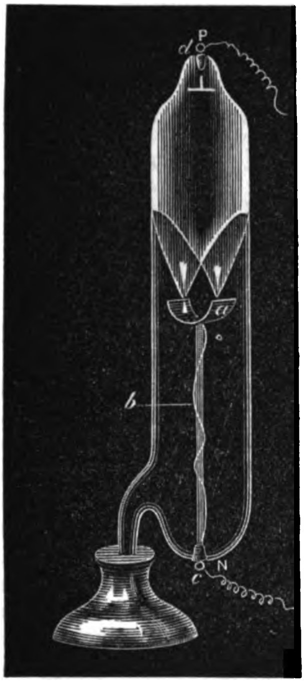


of the bulb, and thence diverging fall on the opposite side and produce a circular patch of green phosphorescent light. As I turn the bulb round you will all be able to see the green patch on the glass. Now observe, I remove the positive wire from the top, and connect it with the side pole (c). The green patch from the divergent negative focus is there still. I now make the lowest pole (d) positive, and the green patch remains where it was at first, unchanged in position or intensity.

We have here another property of Radiant Matter. In the low vacuum the position of the positive pole is of every importance, while in a high vacuum the position of the positive pole scarcely matters at all; the phenomena seem to depend entirely on the negative pole. If the negative pole points in the direction of the positive, all very well, but if the negative pole is entirely in the opposite direction it is of little consequence: the Radiant Matter darts all the same in a straight line from the negative.

If, instead of a flat disk, a hemi-cylinder is used for the negative pole, the Matter still radiates normal to its surface. The (tube before you fig. 6) illustrates this property. It contains, as a negative pole, a hemi-cylinder (*a*) of polished aluminium. This is connected with a fine copper wire, *b*, ending at the platinum terminal, *c*. At the upper end of the tube is another terminal, *d*. The induction-coil is connected so that the hemi-cylinder is negative and the upper pole positive, and when exhausted to a sufficient extent the projection of the molecular rays to a focus is very beautifully shown. The rays of Matter being driven from the hemi-cylinder in a direction normal to its surface, come to a focus and then diverge, tracing their path in brilliant green phosphorescence on the surface of the glass.

6.



Instead of receiving the molecular rays on the glass, I will show you another tube in which the focus falls on a phosphorescent screen. See how brilliantly the lines of discharge shine out, and how intensely the focal point is illuminated, lighting up the table.

Radiant Matter when intercepted by solid matter casts a shadow.

Radiant Matter comes from the pole in straight lines, and does not merely permeate all the parts of the tube and fill it with light, as would be the case were the exhaustion less good. Where there is nothing in the way the rays strike the screen and produce phosphorescence, and where solid matter intervenes they are obstructed by it, and a shadow is thrown on the screen. In this pear-shaped bulb (fig. 7) the negative pole (*a*) is at the pointed end. In the middle is a cross (*b*) cut out of sheet aluminium, so that the rays from the negative pole projected along the tube will be partly intercepted by the aluminium cross, and will project an image of it on the hemispherical end of the tube which is phosphorescent. I turn on the coil, and you will all see the black shadow of the cross on the luminous end of the bulb (*c*, *d*). Now, the Radiant Matter from the negative pole has been passing by the side of the aluminium cross to produce the shadow; the glass has been hammered and bombarded till it is appreciably warm, and at

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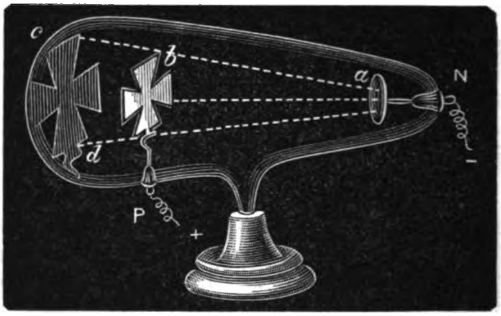


the same time another effect has been produced on the glass—its sensibility has been deadened. The glass has got tired, if I may use the expression, by the enforced phosphorescence. A change has been produced by this molecular bombardment which will prevent the glass from responding easily to additional excitement; but the part that the shadow has fallen on is not tired—it has not been phosphorescing at all and is perfectly fresh; therefore if I throw down this cross,—I can easily do so by giving the apparatus a slight jerk, for it has been most ingeniously constructed with a hinge by Mr. Gimingham,—and so allow the rays from the negative pole to fall uninterruptedly on to the end of the bulb, you will suddenly see the black cross change to a luminous one because the back-ground is now only capable of faintly phosphorescing, while the part which had the black shadow on it retains its full phosphorescent power. The stencilled image of the luminous cross unfortunately soon dies out. After a period of rest the glass partly recovers its power of phosphorescing, but it is never so good as it was at first.

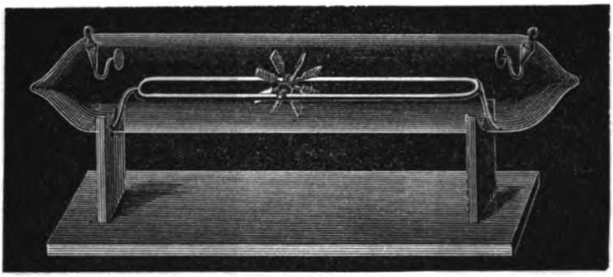
Here, therefore, is another important property of Radiant Matter. It is projected with great velocity from the negative pole, and not only strikes the glass in such a way as to cause it to vibrate and become temporarily luminous while the discharge is going on, but the molecules hammer away with sufficient energy to produce a permanent impression upon the glass.

Radiant Matter exerts strong mechanical action where it strikes.

We have seen from the sharpness of the molecular shadows, that Radiant Matter is arrested by solid matter placed in its path. If this solid body is easily moved the impact of the molecules will reveal itself in strong mechanical action. Mr

Gimingham has constructed for me an ingenious piece of apparatus which when placed in the electric lantern will render this mechanical action visible to all present. It consists of a highly exhausted glass tube (fig. 8), having a little glass railway running along it from one end to the other. The axle of a small wheel revolves on the rails, the spokes of the wheel carrying wide mica paddles. At each end of the tube, and rather above the center, is an aluminium pole, so that whichever pole is made negative the stream of Radiant Matter darts from it along the tube, and striking the upper vanes of the little paddle-wheel causes it to turn round and travel along the railway. By reversing the poles I can arrest the wheel and send it the reverse way, and if I gently incline the tube the force of impact is observed to be sufficient even to drive the wheel up-hill.

8.



This experiment therefore shows that the molecular stream from the negative pole is able to move any light object in front of it.

The molecules being driven violently from the pole there should be a recoil of the pole from the molecules, and by arranging an apparatus so as to have the negative pole movable and the body receiving the impact of the Radiant Matter fixed, this recoil can be rendered sensible. In appearance the apparatus (fig. 9) is not unlike an ordinary radiometer with aluminium disks for vanes, each disk coated on one side with a film of mica. The fly is supported by a hard steel instead of glass cup, and the needle point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer therefore can be connected with an induction-coil, the movable fly being made the negative pole.

For these mechanical effects the exhaustion need not be so high as when phosphorescence is produced. The best pressure for this electrical radiometer is a little beyond that at which the dark space round the negative pole extends to the sides of the glass bulb. When the pressure is only a few millims. of mercury, on passing the induction current a halo of velvety violet light forms on the metallic side of the vanes, the mica side remaining dark. As the pressure diminishes, a dark space is seen to separate the violet halo from the metal. At a pressure of half a millimeter this dark space extends to the glass, and rotation commences. On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, when the rotation becomes very rapid.

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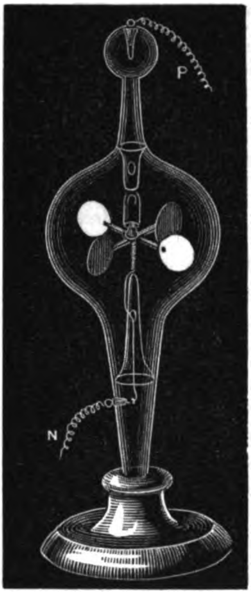

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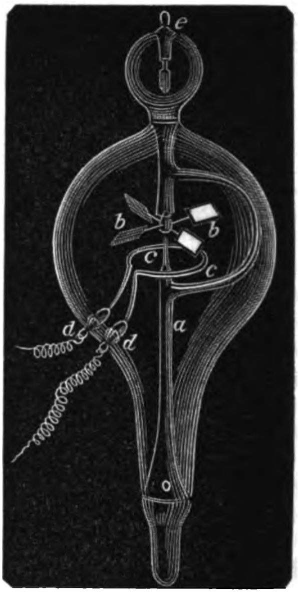


Here is another piece of apparatus (fig. 10) which illustrates the mechanical force of the Radiant Matter from the negative pole. A stem (*a*) carries a needle-point in which revolves a light mica fly (*b b*). The fly consists of four square vanes of thin clear mica, supported on light aluminium arms, and in the center is a small glass cap which rests on the needle-point. The vanes are inclined at an angle of 45° to the horizontal plane. Below the fly is a ring of fine platinum wire (*c c*), the ends of which pass through the glass at *d d*. An aluminium terminal (*e*) is sealed in at the top of the tube, and the whole is exhausted to a very high point.

By means of the electric lantern I project an image of the vanes on the screen. Wires from the induction-coil are attached, so that the platinum ring is made the negative pole, the aluminium wire (*e*) being positive. Instantly, owing to the projection of Radiant Matter from the platinum ring, the vanes rotate with extreme velocity. Thus far the apparatus has shown nothing more than the previous experiments have prepared us to expect; but observe what now happens. I disconnect the induction-coil altogether, and connect the two ends of the platinum wire with a small galvanic battery; this makes the ring *c c* red-hot, and under this influence you see that the vanes spin as fast as they did when the induction-coil was at work.

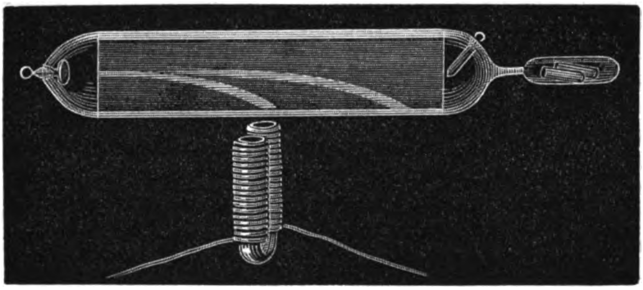
Here, then, is another most important fact. Radiant Matter in these high vacua is not only excited by the negative pole of an induction-coil, but a hot wire will set it in motion with force sufficient to drive round the sloping vanes.

Radiant Matter is deflected by a Magnet.

I now pass to another property of Radiant Matter. This long glass tube is very highly exhausted; it has a negative pole at one end and a long phosphorescent screen down the center of the tube. In front of the negative pole is a plate of mica with a hole in it, and the result is, when I turn on the current, a line of phosphorescent light is projected along the whole length of the tube. I now place beneath the tube a powerful horse-shoe magnet: observe how the line of light becomes curved under the magnetic influence waving about like a flexible wand as I move the magnet to and fro.

This action of the magnet is very curious, and if carefully followed up will elucidate other properties of Radiant Matter. Here (fig. 11) is an exactly similar tube, but having at one end a small potash tube, which if heated will slightly injure the vacuum.

11.

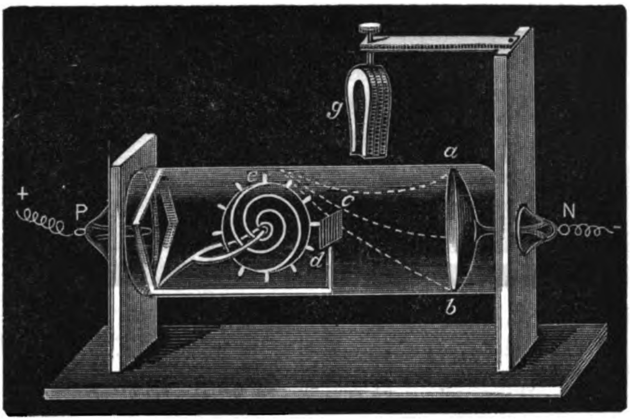


I turn on the induction current, and you see the ray of Radiant Matter tracing its trajectory in a curved line along the screen, under the influence of the horse-shoe magnet beneath. Observe the shape of the curve. The molecules shot from the negative pole may be likened to a discharge of iron bullets from a mitrailleuse, and the magnet beneath will represent the earth curving the trajectory of the shot by gravitation. Here on this luminous screen you see the curved trajectory of the shot accurately traced. Now suppose the deflecting force to remain constant, the curve traced by the projectile varies with the velocity. If I put more powder in the gun the velocity will be greater and the trajectory flatter, and if I interpose a denser resisting medium between the gun and the target, I diminish the velocity of the shot, and thereby cause it to move in a greater curve and come to the ground sooner. I cannot well increase before you the velocity of my stream of radiant molecules by putting more powder in my battery, but I will try and make them suffer greater resistance in their flight from one end of the tube to the other. I heat the caustic potash with a spirit-lamp and so throw in a trace more gas. Instantly the stream of Radiant Matter responds. Its velocity is impeded, the magnetism has longer time on which to act on the individual molecules, the trajectory gets more and more curved, until, instead of shooting nearly to the end of the tube, my molecular bullets fall to the bottom before they have got more than half-way.

It is of great interest to ascertain whether the law governing the magnetic deflection of the trajectory of Radiant Matter is the same as has been found to hold good at a lower vacuum. The experiments I have just shown you were with a very high vacuum. Here is a tube with a low vacuum. When I turn on the induction spark, it passes as a narrow line of violet light joining the two poles. Underneath I have a powerful electro-magnet. I make contact with the magnet, and the line of light dips in the center toward the magnet. I reverse the poles, and the line is driven up to the top of the tube. Notice the difference between the two phenomena. Here the action is temporary. The dip takes place under the magnetic influence; the line of discharge then rises and pursues its path to the positive pole. In the high exhaustion, however, after the stream of Radiant Matter had dipped to the magnet it did not recover itself, but continued its path in the altered direction.

By means of this little wheel, skillfully constructed by Mr. Gimingham, I am able to show the magnetic deflection in the electric lantern. The apparatus is shown in this diagram (fig. 12). The negative pole (*a*, *b*) is in the form of a very shallow cup. In front of the cup is a mica screen (*c*, *d*), wide enough to intercept the Radiant Matter coming from the negative pole. Behind this screen is a mica wheel (*e*, *f*) with a series of vanes, making a sort of paddle-wheel. So arranged, the molecular rays from the pole *a b* will be cut off from the wheel, and will not produce any movement. I now put a magnet, *g*, over the tube, so as to deflect the stream over or under the obstacle *c d*, and the result will be rapid motion in one or the other direction, according to the way the magnet is turned. I throw the image of the apparatus on the screen. The spiral lines painted on the wheel show which way it turns. I arrange the magnet to draw the molecular stream so as to beat against the upper vanes, and the wheel revolves rapidly as if it were an overshot water-wheel. I turn the magnet so as to drive the Radiant Matter underneath; the wheel slackens speed, stops, and then begins to rotate the other way, like an under-shot water-wheel. This can be repeated as often as I reverse the position of the magnet.

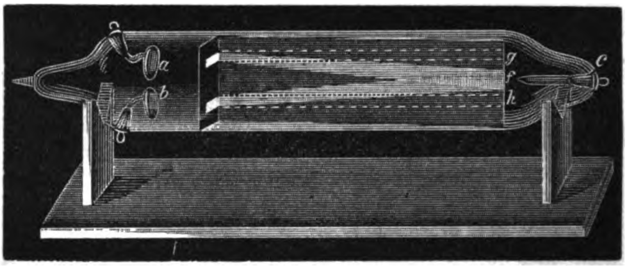
12.



I have mentioned that the molecules of the Radiant Matter discharged from the negative pole are negatively electrified. It is probable that their velocity is owing to the mutual repulsion between the similarly electrified pole and the molecules. In less high vacua, such as you saw a few minutes ago, the discharge passes from one pole to another, carrying an electric current, as if it were a flexible wire. Now it is of great interest to ascertain if the stream of Radiant Matter from the negative pole also carries a current. Here (fig. 13) is an apparatus which will decide the question at once. The tube contains two negative terminals (*a*, *b*) close together at one end, and one positive terminal (*c*) at the other. This enables me to send two streams of Radiant Matter side by side along the phosphorescent screen,—or by disconnecting one negative pole, only one stream.

If the streams of Radiant Matter carry an electric current they will act like two parallel conducting wires and attract one another; but if they are simply built up of negatively electrified molecules they will repel each other.

13.



I will first connect the upper negative pole (*a*) with the coil, and you see the ray shooting along the line *d*, *f*. I now bring the lower negative pole (*b*) into play, and another line (*e*, *h*) darts along the screen. But notice the way the first lien behaves; it jumps up from its first position, *d f*, to *d g*, showing that it is repelled, and if time permitted I could show you that the lower ray is also deflected from its normal direction: therefore the two parallel streams of Radiant Matter exert mutual repulsion, acting not like current carriers, but merely as similarly electrified bodies.

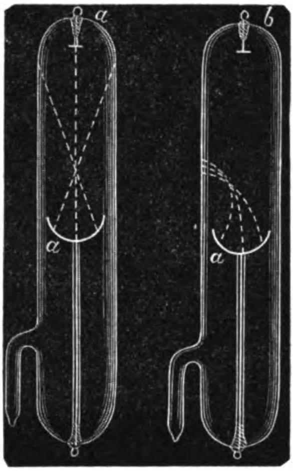
Radiant Matter produces heat when its motion is arrested.

During these experiments another property of Radiant Matter has made itself evident, although I have not yet drawn attention to it. The glass gets very warm where the green phosphorescence is strongest. The molecular focus on the tube, which we saw earlier in the evening (fig. 6) is intensely hot, and I have prepared an apparatus by which this heat at the focus can be rendered apparent to all present.

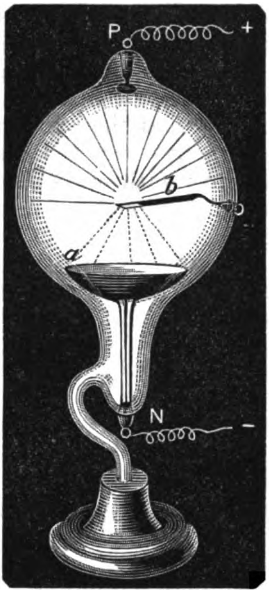
I have here a small tube (fig. 14, *a*) with a cup-shaped negative pole. This cup projects the rays to a focus in the middle of the tube. At the side of the tube is a small electro-magnet, which I can set in action by touching a key, and the focus is then drawn to the side of the glass tube (fig. 14, *b*). To show the first action of the heat I have coated the tube with wax. I will put the apparatus in front of the electric lantern, and throw a magnified image of the tube on the screen. The coil is now at work, and the focus of molecular rays is projected along the tube. I turn the magnetism on, and draw the focus to the side of the glass. The first thing you see is a small circular patch melted in the coating of wax. The glass soon begins to disintegrate, and cracks are shooting starwise from the center of heat. The glass is softening. Now the atmospheric pressure forces it in, and now it melts. A hole is perforated in the middle, the air rushes in, and the experiment is at an end.

I can render this focal heat more evident if I allow it to play on a piece of metal. This bulb (fig. 15) is furnished with a negative pole in the form of a cup (*a*). The rays will therefore be projected to a focus on a piece of iridio-platinum (*b*) supported in the center of the bulb.

14.



15.



I first turn on the induction-coil slightly, so as not to bring out its full power. The focus is now playing on the metal, raising it to a white-heat. I bring a small magnet near, and you see I can deflect the focus of heat just as I did the luminous focus in the other tube. By shifting the magnet I can drive the focus up and down, or draw it completely away from the metal, and leave it non-luminous. I withdraw the magnet, and let the molecules have full play again; the metal is now white-hot. I increase the intensity of the spark. The iridio-platinum glows with almost insupportable brilliancy, and at last melts.

The Chemistry of Radiant Matter.

As might be expected, the chemical distinctions between one kind of Radiant Matter and another at these high exhaustions are difficult to recognize. The physical properties I have been elucidating seem to be common to all matter at this low density.

Whether the gas originally under experiment be hydrogen, carbonic acid, or atmospheric air, the phenomena of phosphorescence, shadows, magnetic deflection, etc., are identical, only they commence at different pressures. Other facts however, show that at this low density the molecules retain their chemical characteristics. Thus by introducing into the tubes appropriate absorbents of residual gas, I can see that chemical attraction goes on long after the attenuation has reached the best stage for showing the phenomena now under illustration, and I am able by this means to carry the exhaustion to much higher degrees than I can get by mere pumping. Working with aqueous vapor I can, use phosphoric anhydride as an absorbent; with carbonic acid, potash; with hydrogen, palladium; and with oxygen, carbon, and then potash. The highest vacuum I have yet succeeded in obtaining has been the 1-20,000,000th of an atmosphere, a degree which may be better understood if I say that it corresponds to about the hundredth of an inch in a barometric column three miles high.

It may be objected that it is hardly consistent to attach primary importance to the presence of *Matter*, when I have taken extraordinary pains to remove as much Matter as possible from these bulbs and these tubes, and have succeeded so far as to leave only about the one-millionth of an atmosphere in them. At its ordinary pressure the atmosphere is not very dense, and its recognition as a constituent of the world of Matter is quite a modern notion. It would seem that when divided by a million, so little Matter will necessarily be left that we may justifiably neglect the trifling residue and apply the term *vacuum* to space from which the air has been so nearly removed. To do so, however, would be a great error, attributable to our limited faculties being unable to grasp high numbers. It is generally taken for granted that when a number is divided by a million the quotient must necessarily be small, whereas it may happen that the original number is so large that its division by a million seems to make little impression on it. According to the best authorities, a bulb of the size of the one before you (13·5 centimeters in diameter) contains more than 1,000000,000000,000000,000000 (a quadrillion) molecules. Now, when exhausted to a millionth of an atmosphere we shall still have a trillion molecules left in the bulb—a number quite sufficient to justify me in speaking of the residue as *Matter*.

To suggest some idea of this vast number I take the exhausted bulb, and perforate it by a spark from the induction coil. The spark produces a hole of microscopical fineness, yet sufficient to allow molecules to penetrate and to destroy the vacuum. The inrush of air impinges against the vanes and sets them rotating after the manner of a windmill. Let us suppose the molecules to be of such a size that at every second of time a hundred millions could enter. How long, think you, would it take for this small vessel to get full of air? An hour? A day? A year? A century? Nay, almost an eternity! A time so enormous that imagination itself cannot grasp the reality. Supposing this exhausted glass bulb, indued with indestructibility, had been pierced at the birth of the solar system; supposing it to have been present when the earth was without form and void; supposing it to have borne witness to all the stupendous changes evolved during the full cycles of geologic time, to have seen the first living creature appear, and the last man disappear; supposing it to survive until the fulfilment of the mathematicians' prediction that the sun, the source of energy, four million centuries from its formation will ultimately become a burnt-out cinder;[*] supposing all this,—at the rate of filling I have just described, 100 million molecules a second—this little bulb even then would scarcely have admitted its full quadrillion of molecules.[†]

But what will you say if I tell you that all these molecules, this quadrillion of molecules, will enter through the microscopic hole before you leave this room? The hole being unaltered in size, the number of molecules undiminished, this apparent paradox can only be explained by again supposing the size of the molecules to be diminished almost infinitely—so that instead of entering at the rate of 100 millions every second, they troop in at a rate of something like 300 millions a second. I have done the sum, but figures when they mount so high cease to have any meaning, and such calculations are as futile as trying to count the drops in the ocean.

In studying this Fourth state of Matter we seem at length to have within our grasp and obedient to our control the little indivisible particles which with good warrant are supposed to constitute the physical basis of the universe. We have seen that in some of its properties Radiant Matter is as material as this table, whilst in other properties it almost assumes the character of Radiant Energy. We have actually touched the border land where Matter and Force seem to merge into one another, the shadowy realm between Known and Unknown which for me has always had peculiar temptations. I venture to think that the greatest scientific problems of the future will find their solution in this Border Land, and even beyond; here, it seems to me, lie Ultimate Realities, subtle, far-reaching, wonderful.

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[*] The possible duration of the sun from formation to extinction has been variously estimated by different authorities, at from 18 million years to 400 million years. For the purpose of this illustration I have taken the highest estimate.

[†] According to Mr. Johnstone Stoney (Phil. Mag., vol. xxxvi. p. 141), 1 c.c. of air contains about 1000,000000,000000,000000 molecules. Therefore a bulb 13·5 centimeters diameter contains $13{\cdot}5^3 \times 0{\cdot}5236 \times 1000,000000,000000,000000$ or 1,288252,350000,000000,000000 molecules of air at the ordinary pressure. Therefore the bulb when exhausted to the millionth of an atmosphere contains 1,288252,350000,000000 molecules, leaving 1,288251,061747,650000,000000 molecules to enter through the perforation. At the rate of 100,000000 molecules a second, the time required for them all to enter will be

12882,510617,476500 seconds, or
214,708510,291275 minutes, or
3,578475,171521 hours, or
149103,132147 days, or
408,501731 years.

> "Yet all these were, when no Man did them know,
> Yet have from wisest Ages hidden beene;
> And later Times thinges more unknowne shall show.
> Why then should witlesse Man so much misweene,
> That nothing is, but that which he hath seene?"

Art. XXXVI.—*On the Coincidence of the Bright Lines of the Oxygen Spectrum with Bright Lines in the Solar Spectrum*; by Henry Draper, M.D.*

I intend in this paper to speak of the steps that led to the discovery of oxygen in the Sun, to describe very briefly some of the successive improvements of the electrical and optical apparatus employed, and finally to discuss the earlier results and to show their subsequent confirmation.

In 1857, after the meeting of the British Association at Dublin, some of the members, by the kindness of the Earl of Rosse, were invited to visit the 6-foot Reflector at Birr Castle. In this way I enjoyed the advantage of seeing the methods by which that great instrument had been produced, and, on returning to America in 1858, it prompted me to begin the construction of a metallic speculum of 15½ inches aperture. Soon after, by the advice of Sir John Herschel, who had early information of Foucault's work in Paris, the metal was abandoned in favor of silvered glass, and several mirrors were ground and polished. The telescope was constructed especially for photography, and good results were obtained in 1863, culminating in the production of a photograph of the Moon fifty inches in diameter. These were published in the Smithsonian Contributions to Science for the succeeding year. The success procured with this instrument prepared the way for making a silvered glass Equatoreal of twenty-eight inches aperture, which was ready for use

* Read before the Royal Astronomical Society, June 13th, 1879, and reprinted from advance sheets of the Monthly Notices. This Journal is indebted for the cuts illustrating this article, to the Astronomical Society.

in 1871, though it has been much modified since. It was obvious that increased light-collecting power and precise equatoreal movements were necessary for the modern applications of physics to astronomy. More recently still there has been attached to the same equatoreal stand an achromatic telescope of twelve inches aperture made by Alvan Clark & Sons, this being particularly intended for solar spectroscopic work.

Soon after the 28-inch Reflector was turned to stellar and planetary photographic spectroscopy it became evident that the results obtained required for their interpretation photographs of metallic and non-metallic spectra, so that comparisons might be instituted leading to precise knowledge of the elements producing lines at the more refrangible end of the spectrum. This led to a division of the work into two parts, one for the Observatory in the country in the warmer half of the year, the other for my town laboratory during the winter. It was in the latter that most of the oxygen work has been done, and consequently the engine, the Gramme machine, the induction coil, and the large spectroscope are generally there.

My first photographs of metallic spectra were taken with such apparatus as happened to be at hand, viz: a couple of Bunsen's batteries, an induction coil giving a spark of one-half inch, and a Hofmann's direct-vision spectroscope. The length of the spectrum from G to H was about half an inch, but, though the dimensions were small, the promise was great. After some experiments, however, and after obtaining more powerful instrumental appliances, it seemed best, as able physicists were engaged on the metallic spectra, to turn attention more particularly to photographing the spectra of the non-metals. The exceedingly valuable researches of Dr. Huggins had brought the astronomical importance of nitrogen, carbon and hydrogen into notice, and these accordingly were next the subject of experiment. Not long after, on examining a series of photographs of the fluted spectrum of nitrogen taken with juxtaposed solar spectra, the suspicion that there was a coincidence of some bright bands in the two spectra was suggested. On pursuing the subject with more and more powerful electrical and optical arrangements, the coincidence of bright lines of oxygen with bright lines in the solar spectrum was discovered.

The original apparatus, as has been said above, was on a very small scale, but it was soon replaced by a larger battery, a 2-inch induction coil, and a direct-vision prism of one inch aperture by Browning. The electrical part was made more and more powerful as the research proceeded, the 2-inch induction coil being succeeded by one of six inches, and that in turn by a Ruhmkorff coil capable of giving a spark of seventeen inches. The battery was eventually superseded by a Gramme dynamo-electric machine which can produce a current powerful enough to give, between carbon points, a light equal to 500 standard candles. When this machine is properly applied to the 17-inch induction coil, it will readily give 1,000 10-inch sparks per minute. These, being condensed by fourteen Leyden jars, communicate an intense incandescence to air, and light enough is produced to permit of the use of a narrow slit, and of a collimator and telescope of long focus.

Since 1877, when the first publication of the discovery of oxygen in the Sun was made, still further improvements, especially in the optical parts, have been completed, so that I am now enabled to photograph the oxygen spectrum with four times the dispersion then employed. For the sake of clearness, it is best to give a brief description: 1st, of the electrical part; and 2nd, of the optical part.

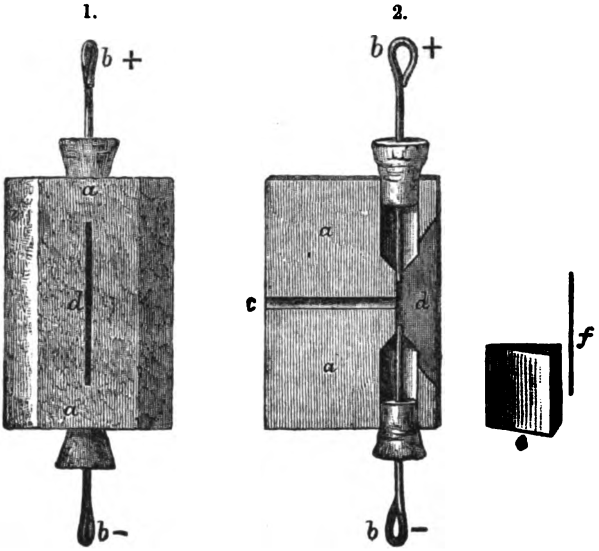
The electrical part consists of the Gramme machine and its driving engine, the induction coil, the Leyden jars, and the terminal or spark compressor. An advantage the Gramme has over a battery is in the uniformity of the current it gives when an uniform rate of rotation of its bobbin is kept up. Of course this implies the use of a prime mover that is well regulated. The petroleum engine of one and a half horse-power I have employed is convenient and safe and does this duty well. As to the Gramme itself, it is only needful to call attention to a modification of the interior connections. In one form the bobbin of wire which revolves between the magnets is double, so that the current produced may be divided into two. Under ordinary circumstances, where the machine is used to produce light, both sides of the bobbin send their currents through the electro-magnets. But if the whole current be sent through a quick-working break circuit into an induction coil, the electro-magnets do not become sufficiently magnetised to produce any appreciable effect. It is expedient, therefore, to arrange the connections so that one-half of the bobbin gives a continuous current through the electro-magnets and keeps up the intensity of the magnetic field, and then the current from the other half of the bobbin may be used for exterior work, whether continuous or interrupted.

At first a Foucault mercurial interruptor was arranged to make and break the current passing into the primary circuit of the induction coil; but during the past year, by carrying the rate of rotation of the Gramme up to 1,000 per minute, the strength of the current has been so much increased that the mercury was driven violently out of the cup, and hence it was essential to arrange a mechanical break in which solid metal alone was used. This has been accomplished by fastening on the axis of the Gramme bobbin a wheel with an interrupted rim, which serves the purpose well.

As to the induction coil, it is only needful to say that it gives a good thick spark, which is limited to twelve inches to avoid the risk of injuring the insulation. The Leyden jars are fourteen in number, having altogether seven square feet of coating on each surface.

The arrangement of the terminals from the Leyden jars to get the steadiest and brightest effect has offered great difficulties. The condensed spark taken in the open air or in a gas under atmospheric pressure pursues, if unconfined, a zigzag course, and this is apt to produce a widening of the lines in the photographed spectrum. But, after many experiments, it turned out that the spark might be compressed between two plates of thick glass, or, better yet, between two plates of soapstone. If the interval between the plates was directed toward the slit of the spectroscope the lateral flickering of the spark was prevented, and yet at the same time the spark was freely exposed to the slit without the intervention of glass or any substance on which the volatilized metal from the terminals could deposit. Very early in this research it had become apparent that Plücker's tubes could not be employed with electrical currents of more than a certain intensity, partly on account of the deposit that took place in the capillary portion, and partly because the terminals became so hot as to melt and crack the glass. Moreover, it was desirable to use one terminal of iron, so as to be sure that the spectrum of the gas was correctly adjusted to the solar spectrum, and this is impracticable with Plücker's tubes. An additional advantage arises from the soapstone plates, viz: the temperature of the small volume of air between the terminals is materially increased, and increased brightness results. I have tried the effect of warming the air by passing it through a coil of brass tube maintained at a bright red heat, but this does not seem to make any perceptible difference when the terminals are enclosed in the spark compressor.

The optical part of my apparatus has undergone many modifications. At first a Hofmann direct-vision prism was combined with a lens of six inches focus; this was soon after replaced by a Browning direct-vision prism and a lens of eighteen inches focus, the latter being arranged for conjugate foci, so that it was virtually as if collimating and observing lenses of thirty-six inches focus were employed. The final system, perfected this winter, consists of a collimator of two inches aperture and twenty-six inches focus, succeeded by two bisulphide of carbon prisms of two inches aperture and an observing or photographing lens of six feet six inches focal length. These prisms belong to Mr. Rutherfurd and are the same he made for producing his celebrated solar prismatic spectrum. This gives a dispersion of about eight inches between G and H and enables



Spark Compressor: 1, front view; 2, section in plane of narrow opening; *aa*, soapstone; *bb*, terminals; *c*, aperture for introducing gases; *d*, narrow opening to spark; *e*, right-angled prism; *f*, slit of spectroscope.

3.

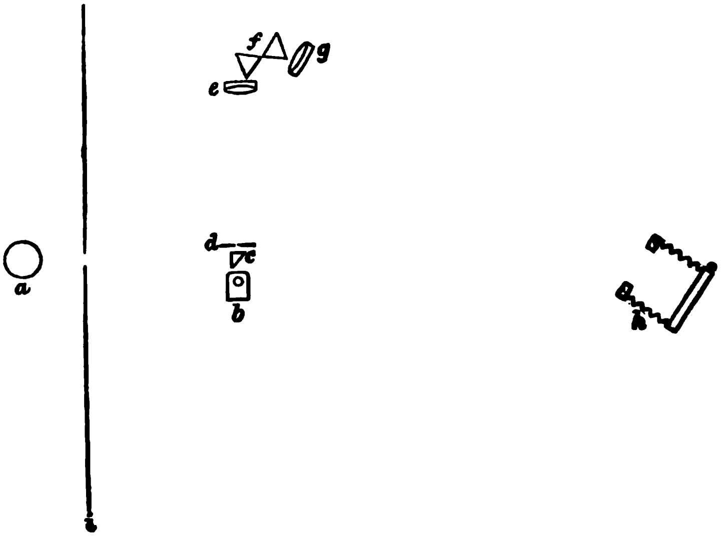


Diagram of Photographic Spectroscope: *a*, heliostat mirror; *b*, spark compressor; *c*, right-angled prism; *d*, slit; *e*, collimator; *f*, two bisulphide prisms; *g*, photographic objective; *h*, camera; *i*, window shutter.

me to get original negatives on a scale about half the size of Ångström's charts in the Spectre Normal du Soleil. When it is remembered that the light produced by the electric current in the spark compressor is scarcely equal to one standard candle, it will be realized that this great dispersion nearly attains the limit of present possibility. By comparison I have found, when the electric arc from this Gramme volatilizes iron, the light is sixty times stronger than the most vivid incandescence of air that I have produced.

The slit of the spectroscope is about one inch long, and opposite the lower half is placed a right-angled prism which serves to bring in a beam of sunlight from a heliostat. We thus have the solar spectrum and the air spectrum upon the plate at the same time, so that the two spectra on the negative are, strictly speaking, simultaneously produced. Moreover, by the aid of a magnifier we can ascertain, just previous to an exposure, whether the adjustments are in the best order. It is not commonly known that, to obtain the last degree of exactness in coincidence between a solar and an air spectrum, many precautions are necessary, and that is the reason it is desirable to have iron vapor present at one of the poles so as to determine the reliability of the coincidence by comparing iron in the spark spectrum with iron in the Sun.

Having thus alluded to some of the principal peculiarities of the apparatus constructed for this research, it is proper in the next place to point out the nature of the evidence afforded by the photographs of the presence of oxygen in the Sun. The first photographs were on so small a scale that they did not even give rise to a suspicion of this fact, and it was not until 1876 that I felt sufficiently sure to make any publication. At this time the original negatives were about two inches long from G to H, and they bore an enlargement of three or four times quite well. The Albertype printed in 1877 in Nature, the Comptes Rendus, and this Journal, was produced from such an enlargement. Since that time, in order to meet the criticism that perhaps the dispersion was not sufficient to disclose the lack of coincidence if such existed, I have increased the dispersion four times and am thus enabled to make enlarged photographs on a scale about twice the size of Ångström's chart. Enlargements of the juxtaposed spectra of air and Sun on this scale are now presented for inspection.

Of course an enlargement never does justice to the original from which it was produced, and, in order to study the matter faithfully, the negative must be examined carefully with a magnifier. Beside this, owing partly to the fact that the solar spectrum has suffered from absorptive influences, both in the Earth's atmosphere and in the solar atmosphere, the conditions under which the oxygen spectrum is seen when compared with the spark spectrum are modified. In fact, a critical study of the two spectra demands that each line of oxygen should be separately photographed with the corresponding region of the Sun's spectrum, so as to reproduce as nearly as possible the same conditions for each. As an instance of the modifications which may be caused by the solar atmosphere, the superposition of absorption lines on the bright lines of oxygen may be mentioned. If, as seems to be the case, the stratum giving the oxygen spectrum in the Sun lies deeper than the reversing layer in which iron exists, I see no reason why an iron absorption line, for instance, may not fall upon an oxygen bright band. In support of this supposition that oxygen is photospheric, it may be stated that, though I have examined the chromosphere on many occasions, I have not as yet seen the bright oxygen lines project beyond the apparent limb of the Sun as observed in the spectroscope, although several of the chromosphere lines catalogued by Young were readily visible. On consulting with Professor Young, he expressed the opinion that the oxygen groups near G did not appear as bright lines in the chromosphere, even under the exceptionally favorable circumstances he enjoyed at Sherman. For the purpose of continuing the study of this point, and also of examining small areas on the Sun, faculæ, spots, etc., Alvan Clark & Sons are constructing a special spectroscope for me which can give the dispersion of twenty heavy flint prisms and can bear high magnifying power.

If it be conceded that there are bright lines in the spectrum of the solar disk, which seems to be the opinion of several physicists, and especially Lockyer, Cornu and Hennessy, the question of their origin naturally attracts attention. It seems that there is great probability, from general chemical reasons, that a number of the non-metals may exist in the Sun. The obvious continuation of this research is in that direction. But the subject is surrounded by exceedingly great obstacles, arising principally from the difficulty of matching the conditions as to temperature, pressure, etc., found in the Sun. Any one who has studied nitrogen, sulphur, or carbon, and has observed the manner in which the spectrum changes by variations of heat and pressure, will realize that it is well-nigh impossible to hit upon the exact conditions under which such bodies exist at the level of the photosphere. The fact that oxygen, within a certain range of variation, suffers less change than others of the non-metals has been the secret of its detection in the Sun. It appears to have a greater stability of constitution, though Schuster has shown that its spectrum may be made to vary. I have already begun an extended series of experiments on the non-metals; but the results exhibit such confusion that their bearing cannot at present be distinctly seen. In the case of nitrogen the broad bands between G and H exhibit, under the most intense incandescence, a tendency to condense into narrow bands or lines, and indeed there are some sharp lines of nitrogen in the photographs now presented.

It does not follow, therefore, that the bright bands of oxygen are necessarily the brightest parts of the solar spectrum. Other substances may produce lines or bands of greater brilliancy.

There is also another cause for a difference of appearance in a bright-line spectrum produced in a laboratory and bright lines in the Sun. While the edges of a band in the spark spectrum may be nebulous or shaded off, the corresponding band in the solar spectrum may have its edges sharpened by the action of adjacent dark lines due to one or another of the metallic substances in the Sun.

On the whole, it does not seem improper for me to take the ground that, having shown by photographs that the bright lines of the oxygen spark spectrum all fall opposite bright portions of the solar spectrum, I have established the probability of the existence of oxygen in the Sun. Causes that can modify in some measure the character of the bright bands of the solar spectrum obviously exist in the Sun, and these, it may be inferred, exert influence enough to account for such minor differences as may be detected.

In closing, it may be well to give some idea of the amount of labor and time this research has already consumed, and this cannot be better done than by a statement of the production of electrical action that has been necessary. Each photograph demands an exposure of 15 minutes, and, with preparation and development, at least half an hour is needed. The making of a photograph, exclusive of intermediate trials, requires, therefore, about 30,000 10-inch sparks, that is 30,000 revolutions of the bobbin of the Gramme machine. In the last three years the Gramme has made 20 millions of revolutions. The petroleum engine only consumes a couple of drops of oil at each stroke, and yet it has used up about 150 gallons. Each drop of oil produces two or three 10-inch sparks. It must also be borne in mind that comparison spectra can only be made when the Sun is shining, and clouds therefore are a fertile source of loss of time.

APPENDIX.

[We find in the Astronomical Register a Report of the Discussion which followed the reading of Dr. Draper's paper. As this is the expression of the opinion of the best English authorities upon the conclusions reached in the memoir and as it will be seen, we suppose, by but few of our readers, we present it in pretty full abstract, as a matter of general interest.—EDS.]

After the reading of the paper, Dr. Draper showed some exquisitely sharp negatives of the solar and oxygen spectra, which he had obtained, and handed round some paper enlargements, some two feet long, for inspection by the meeting.

Mr. Ranyard: After the reception that has been given to Dr. Draper, I do not think I need say anything about the importance of the research he has undertaken. When a couple of years ago he sent over copies from his former photographs on a much smaller scale, I then ventured to say that I thought the probability of the proposition which he laid down was very great indeed, amounting to some thousands to one, and I should like now to point out how enormously the probability has been increased by these more recent experiments. If Dr. Draper has increased his dispersion four times he has not merely increased the probability of his case four times, but he has increased the value of every coincidence he shows four times. On looking at the original photographs (which show the coincidences more sharply than the paper prints) I counted eighteen oxygen lines, and, therefore, the increase of probability on the present occasion, as compared with the former occasion, is as four to the power of eighteen to one, a very enormous number. There are two or three ways of looking at the probability of the proposition which Dr. Draper has laid down, that the bright lines of oxygen coincide with the bright lines in the solar spectrum. In the first place, there is the chance that the center of no single line of oxygen should fall opposite to a dark line or space in the solar spectrum. If a line were thrown at random beside the solar spectrum the chance that it should fall opposite to a bright part of the solar spectrum would be as the total breadth of the bright part of the solar spectrum to the total breadth of the dark part of the solar spectrum. Let us suppose that the breadth occupied by dark lines in the solar spectrum is equal to the breadth occupied by bright lines (probably as seen with high dispersion this is well within the truth) then the chance of any oxygen line falling opposite to a bright line or interspace in the solar spectrum would be one-half, and if the eighteen lines of oxygen had been thrown down at random beside the solar spectrum, the chance that the center of all the lines should fall opposite to bright spaces would be one divided by two to the power of eighteen. In addition to this we must take into account the chances of the centers of the bright lines appearing to coincide with the centers of the bright interspaces where they do coincide, for in some instances the interspaces are double the breadth of the corresponding oxygen line, the oxygen line being on one side and coinciding with one edge of the interspace; but this is accounted for by the fact that there are probably other bright lines in the solar spectrum besides oxygen lines, and two such bright lines happen, in some instances to fall together. Then, also, it must be remembered that the light of the bright lines of the solar spectrum has suffered absorption in the solar atmosphere, and in the earth's atmosphere, so that they may be modified by the superposition of absorption lines. The observations of the bright lines seen at the limb of the Sun renders it probable that the layer of the solar atmosphere, which gives rise to the dark lines, lies above the layer from which we receive the light of the bright oxygen spectrum, for no bright oxygen lines are seen in the chromosphere. So that it is possible to conceive that the oxygen lines of the solar spectrum may be modified as we observe them by the superposition of dark lines, and this appears in one or two instances to have been the case; but the character of the bright interspaces is very little changed. If, after examining the photographs, anybody has still any doubts as to the case made out by Dr. Draper, I think that he will feel obliged to them if they will state their objections, and give him an opportunity of discussing them.

Mr. Christie: I do not feel exactly competent to enter on this question very deeply, but Dr. Draper has very kindly given me an opportunity of examining his very beautiful photographs, and I cannot help expressing my great admiration at the splendid results he has achieved. He has obtained photographs of the spectrum of oxygen which, as far as my rather limited acquaintance with the subject goes, are far superior to anything else of the kind; but that is quite another question from proving the existence of oxygen in the Sun. I am afraid that is a very difficult question he has undertaken. If he could prove it, I think these photographs would go a very long way. I do not see myself that there is, as he has expressed it, very much more to be done in the matter. But I am sorry to say it seems to open up to me rather a hopeless prospect, because we are brought face to face with a great difficulty. Dr. Draper was very kind in explaining to me his views, and he did not at all shirk the difficulties of the case. I hope I may be justified in alluding to them, simply for the sake of getting at the truth. According to Dr. Draper's supposition, the solar spectrum is made up of a continuous spectrum with dark absorption lines, and also bright lines superposed upon it. Now, the ordinary spectrum, which up to the present time we have supposed that we had to deal with, was a continuous spectrum with dark lines, but when you superpose on this bright lines, so faint that you cannot distinguish their brightness from the general background of the spectrum, it is evident that the problem becomes more complicated. I do not want to express any opinion one way or the other. I am in the position of a sceptic; it may be an unfortunate position, but I think it is a truly scientific position. Now, taking the position of a sceptic, one has to examine these photographs and look to whether Dr. Draper has shown the coincidences as Mr. Ranyard asserts; if not, his probabilities fall to the ground. In more than one instance I find an oxygen line opposite a broader bright space in the solar spectrum, which appears of identically the same brightness in its whole breadth. If the broader space consists of two or more bright lines, as has been suggested, we have two difficulties to contend with; in the first place we have to show that there are other substances which would give lines corresponding to the unoccupied breadth of the interspace, and in the second place we have the fact that these lines are undistinguishable in brightness from the oxygen lines. Again, each of the oxygen lines is fuzzy at the edges, and as there is nothing analogous in the solar spectrum, we have to suppose that the fuzzy edges are cut off by adjacent dark lines. Now, if we are to make use of probabilities, I would ask what is the probability of a pair of dark lines falling in every case exactly at the edges of an oxygen line? We must also take into account the fact that former physicists have failed to identify any of the bright lines of oxygen with dark lines in the solar spectrum, and therefore we start with the fact that none of the oxygen lines can fall opposite to dark lines.

Mr. Proctor said: There are one or two points I should like to mention. I do not think that Mr. Christie has sufficiently taken into account the importance of the fact that all the oxygen lines fall entirely opposite to bright interspaces in the solar spectrum, and that none of them even partially overlap dark lines. With regard to the general character of the solar spectrum, I would like to ask those who have more especially studied the subject, whether it does not seem probable from antecedent considerations that the solar spectrum should be purely gaseous in its character, that is to say, that there should be bright and dark lines, but no continuous background of spectrum. Perhaps some of you have considered the bearing of Mr. Croll's researches on this matter. He considers that the earth affords evidence that the solar system has been in existence for more than 20,000,000 of years, whereas, if the Sun has been giving out energy as at present for 20,000,000 years, we know that it cannot have derived it from shrinking from even an infinite volume to a globe as large as the photosphere. I am not inclined to agree with him in his explanation that the solar energy may in part have been derived from the impact of stars, but rather think that it points to the fact that the real mass of the Sun lies very much within the photosphere, and that if there is any solid or liquid nucleus, it is only at a depth of many thousands of miles below the photosphere. If that is the case, I would ask whether it is antecedently probable that there should be any continuous background in the solar spectrum. If the photosphere is purely gaseous, we should only have bright bands interfered with and modified by absorption lines.

Dr. Gladstone: I have listened with the greatest attention to Dr. Draper. When the photographs first came over I was not convinced, but certainly he has produced results, which, as Mr. Ranyard has shown, have largely increased the evidence of there being real coincidences between the oxygen lines and bright spaces in the solar spectrum. There seems to be still a great question as to whether the solar spectrum is made up only of bright and dark lines, or whether there is a background of continuous spectrum. I am not disposed to give up the idea that we have a continuous spectrum underlying these dark lines, but think that it is certain that we have also bright lines mixed with the dark. We know that when we look at the edge of the Sun there are bright lines corresponding to hydrogen, and some other elements to be seen, but there are no oxygen lines. Now, I would suggest that this shows that the oxygen never rises to the level of the chromosphere, so as to be seen at the limb of the Sun, and probably that is just the reason why we see its lines as bright lines and not as dark lines, for it never gets up to a level where it is sufficiently cool to form dark lines. We can easily understand that, with so much iron and magnesium vapor, all the oxygen as it rushes upward to the higher levels may enter into combination and fall in a rain of oxides.

Dr. Huggins said that he had examined Dr. Draper's photographs, and was overwhelmed with a sense of the large amount of conscientious labor and care which he had evidently bestowed upon the investigation. Dr. Draper had made out a *primâ facie* case, which entitled him to demand a careful examination of the evidence he had brought forward; but for his own part he should like to suspend his judgment until he had had an opportunity to reëxamine that part of the spectrum. He preferred to wait for a little light, a little sunlight, on the subject, but he wished now to state how thoroughly impressed he was with the cautious and careful experimental arrangements which Dr. Draper had adopted.

Capt. Noble: It seems to me, looking at the photographs impartially, that if we are to deny the evidence supplied by some of these coincidences, and notably by this group of four lines, and accept Mr. Christie's dicta, we literally should have no tangible evidence as to the existence of any element in the Sun at all.

Mr. Ranyard: I should like to refer to one or two of the objections raised by Mr. Christie. I understood him to urge as an objection that there are a great many bright spaces which have not been matched with the bright lines of non-metallic elements. But I would remind him that there are also many dark lines which have not been matched with the lines of known elements. Perhaps they will never be matched, for the conditions in the Sun may not correspond to the conditions obtainable in our laboratories. With regard to the bright lines falling opposite interspaces which are broader than the bright lines of oxygen, the probability is, as Mr. Christie states, very great against their being two adjacent bright lines of exactly equal brightness, but it must be remembered that we are not examining the bright lines themselves, but only photographs of the lines, and that the bright parts of these photographs are what would be called by photographers over-exposed, and, consequently, the gradations of brightness are very much obliterated. Again, I understood Mr. Christie to say that if, instead of matching oxygen lines with interspaces, you began the other way, you ought to find the brightest lines of the spectrum matching the oxygen lines, but this involves the assumption that oxygen gives brighter lines than any other element in the Sun. But I would ask what reason we have for assuming that oxygen gives brighter lines than any other element? With regard to the probability of there being a continuous background of brightness in the solar spectrum, it should be remembered that there are theoretical considerations which render it probable that there is always such a continuous background more or less faint between the bright lines in the spectrum of a gas—when the pressure is considerable the brightness of the continuous part of the spectrum is conspicuous; but theoretically there will always be a continuous spectrum corresponding to the short interval of time after the impact of molecules during which the jar of the collision lasts. In the free path between the impacts they give out the characteristic wave lengths, but however rare the gas I suppose there will always be some continuous spectrum corresponding to the impacts, and with the spectra of a great many gaseous elements superposed the continuous spectrum may be conspicuous. We need not, therefore, assume if we should find evidence of such a continuous spectrum that there is any solid or liquid matter in the photosphere; and if it should turn out that there are no oxygen lines above the photosphere, it will not, I think, follow that there is no oxygen there, for there seems to be evidence that the spectrum of some of the elements changes materially at different altitudes, for example, the 1474 line is the brightest of the bright lines in the corona, but it is a very faint line at the level of the reversing layer, and D_3 is a very bright line in the lower chromosphere, but there is no dark line corresponding to it.

Mr. Christie: I should not have risen except that reference had been made to my remarks. I do not know that I should say very much, but I think I may remark with reference to this question of coincidence, that everything turns upon the exactness of the coincidence, and whether these are actually coincidences or not. I am not quite prepared to admit that these coincidences are perfect; in fact, I should say there are even coincidences of dark lines with some of the oxygen lines. I admit that it is a matter of judgment, and I should be sorry to say positively that there are such coincidences with dark lines. But there is considerable uncertainty in the matter. As Dr. Draper has explained there is a great difficulty in establishing coincidences, and you have to adjust your apparatus until you match coincidences by the known lines of iron. It seems some of these do not coincide exactly with the dark lines in the sun. I only alluded to that as being one of the difficulties we have to contend with. With regard to Mr. Ranyard's remarks as to the eye perceiving differences of brightness which the photographs do not show, I would merely wish to ask whether he has examined with his eye different parts of the spectrum, for there is a certain part in the neighborhood of the G lines which I have examined and find the photograph gives exactly the same appearance as is seen with the eye, i. e., the whole space is of equal intensity. I do not think there is much difference between the photograph and the spectrum as seen with the eye. The only object of my remarks was to clear the ground and to point out what it is we are assuming when we predicate the existence of oxygen as giving bright lines in the sun. I do not dispute it, but only point out the difficulties we must face in order that they may be fairly met.

Mr. J. Rand Capron: There is one question I should like to ask Dr. Draper, and that is, whether he had tried any experiments with the tube spectrum of oxygen?

Dr. Draper: A great many.

Mr. J. Rand Capron: The spark taken in air would probably hardly agree with the spectrum of oxygen near the sun's body. I have had occasion to photograph simultaneously the tube spectrum of hydrogen and the air spark spectrum at ordinary pressures. The tube spectrum of hydrogen showed four hydrogen lines perfect throughout, but only one of these lines was represented in the spectrum of air at ordinary pressure, so that it is possible certain oxygen lines present in the sun may be absent in the spark spectrum.

Dr. Draper: I have taken the oxygen spectrum under a great many different circumstances. I began with tubes containing oxygen and compounds of oxygen, but the difficluty is that you are limited to rather small dispersion, because you cannot get brightness enough for a larger apparatus. Then the difficulty of having iron terminals so as to show a good coincidence is a serious one. So when I made the spark-compressor I arranged a contrivance at the back which would enable me to let in oxygen and the other gases between the terminals, and after various experiments with oxygen I find that it seems to suffer less change with altered conditions than a great many of the other elements I have experimented on. I have fairly shown that the bright lines coincide with bright spaces in the solar spectrum. The minor differences may be fairly attributed to such changes of condition as Mr. Rand Capron has referred to. With regard to Dr. Gladstone's remark, which was that probably we should not find in the chromosphere the lines of the oxygen spectrum. That is precisely what I hope will be the case, although I am going to look as hard as I can for them. I should like to see them if they are there, but I shall be better satisfied if they are not.

A cordial vote of thanks was then passed to Dr. Draper.

[The photographs of the oxygen spectrum and juxtaposed solar spectrum, were also presented to the French Academy of Sciences in Paris, at the meeting of June 23, 1879, by M. A. Cornu. M. Faye made the following remarks, which we translate from the Comptes Rendus.—EDS.]

"I cannot refrain from adding some words to the brilliant communication that the Academy has just heard. Everything leads us to believe that the constitution of the photosphere and its marvellous alimentation, are due to alternate phenomena of chemical combination and dissociation operating at divers temperatures in the mass of the Sun under the influence of ascending and descending vertical movements. Such at least is the idea I have arrived at, by the study of spots, of the problem which I think I have presented in all its fulness. Naturally, the richness in oxygen of the compounds which constitute the earth's crust, though the proportion diminishes little by little as we descend, ought to cause us to believe that this same element should play an analogous part in the Sun; but it is a remarkable thing that up to the present, spectrum analysis has not given any trace of it. On the other hand, it showed that round that star there was a vast atmosphere of hydrogen almost pure and very much rarified, of which certain portions, frequently drawn downward by the mechanical action of solar whirlwinds, gave origin, in ascending again, to the phenomena of the protuberances.

Mr. H. Draper has, however, succeeded in discovering the oxygen, not in the chromosphere, but in the photosphere, where it discloses itself by bright lines. It is obvious that if this gas is dissociated at a depth, it is immediately taken up by multiple combinations in the region and at the temperature of the brilliant surface. I see in these facts the hope of a confirmation and above all of an extension of the views I have put forth on the constitution of the Sun; but whatever may be the fate that the progress of spectrum analysis reserves to them, I express here my admiration for the discovery of Mr. Draper, and I hope that his results, so well confirmed by the photographic proofs that our learned member M. Cornu has shown to the Academy, will not delay in being universally accepted by competent judges."

ART. XXXVII.—*On the Vapor-Densities of Peroxide of Nitrogen, Formic Acid, Acetic Acid, and Perchloride of Phosphorus;* by J. WILLARD GIBBS.

THE relation between temperature, pressure, and volume, for the vapor of each of these substances differs widely from that expressed by the usual laws for the gaseous state,—the laws known most widely by the names of Mariotte, Gay-Lussac, and Avogadro. The *density* of each vapor, in the sense in which the term is usually employed in chemical treatises, i. e., its density taken relatively to air of the same temperature and pressure,* has not a constant value, but varies nearly in the ratio of one to two. And these variations are exhibited at pressures not exceeding that of the atmosphere and at temperatures comprised between zero and 200° or 300° of the centigrade scale.

Such anomalies have been explained by the supposition that the vapor consists of a mixture of two or three different kinds of gas or vapor, which have different densities. Thus it is supposed that the vapor of peroxide of nitrogen is a gas-mixture, the components of which are represented (in the newer chemical notation) by NO_2 and N_2O_4 respectively. The densities corresponding to these formulæ are 1·589 and 3·178. The density of the mixture should have a value intermediate between these numbers, which is substantially the case with the actual vapor. The case is similar with respect to the vapor of formic acid, which we may regard as a mixture of CH_2O_2 (density 1·589) and $C_2H_4O_4$ (density 3·178), and the vapor of acetic acid, which we may regard as a mixture of $C_2H_4O_2$ (density 2·073) and $C_4H_8O_4$ (density 4·146). In the case of perchloride of phosphorus, we must suppose the vapor to consist of three parts; PCl_5 (the proper perchloride, density 7·20), PCl_3 (the protochloride, density 4·98), and Cl_2 (chlorine, density 2·22). Since the chlorine and protochloride arise from the decomposition of the perchloride, there must be as many molecules of the type Cl_2 as of the type PCl_3. Now a gas-mixture containing an equal number of molecules of PCl_3 and Cl_2 will have the density $\frac{1}{2}(4\cdot98+2\cdot22)$ or 3·60. It follows that at least so far as the range of the possible values of its density is concerned, we may regard the vapor as a mixture in variable proportions of two kinds of gas having the densities 7·20 and 3·60 respectively. The observed values of the density accord with this supposition.

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* The language of this paper will be conformed to this usage.

These hypotheses respecting the constitution of the vapors are corroborated, in the case of peroxide of nitrogen and perchloride of phosphorus, by other circumstances. The varying color of the first vapor may be accounted for by supposing that the molecules of the type N_2O_4 are colorless, while each molecule of the type NO_2 has a constant color. This supposition affords a simple relation between the density of the vapor and the depth of its color, which has been verified by experiment.*

The vapor of the perchloride of phosphorus shows with increasing temperature in an increasing degree the characteristic color of chlorine. The amount of the color appears to be such as is required by the hypothesis respecting the constitution of the vapor on the very probable supposition that the perchloride proper is colorless; but the case hardly admits of such exact numerical determinations as are possible with respect to the peroxide of nitrogen.† But since the products of dissociation are in this case dissimilar, they may be partially separated by diffusion through a neutral gas, the lighter chlorine diffusing more rapidly than the heavier protochloride. The fact of dissociation has in this way been proved by direct experiment.‡

In the case of acetic and formic acids, we have no other evidence than the variations of the densities in support of the hypothesis of the compound nature of the vapor, yet if these variations shall appear to follow the same law as those of the peroxide of nitrogen and the perchloride of phosphorus, it will be difficult to refer them to a different cause.

But however it may be with these acids, the peroxide of nitrogen and the perchloride of phosphorus evidently furnish us with the means of studying the laws of chemical equilibrium in gas-mixtures in which chemical change is possible and does in fact take place, reversibly, with varying conditions of temperature and pressure. Or, if from any considerations we can deduce a general law determining the proportions of the

* Salet, "Sur la coloration du peroxyde d'azote." Comptes Rendus, t. lxvii, p. 488.

† H. Sainte-Claire Deville, "Sur les densités de vapeur." Comptes Rendus, t. lxii, p. 1157.

‡ Wanklyn and Robinson. "On Diffusion of Vapours: a means of distinguishing between apparent and real Vapour-densities of Chemical Compounds. Proc. Roy. Soc., vol. xii, p. 507.

component gases necessary for the equilibrium of such a mixture under any given conditions, these substances afford an appropriate test for such a law.

In a former paper* by the present writer, equations were proposed to express the relation between the temperature, the pressure or the volume, and the quantities of the components in such a gas-mixture as we are considering—a *gas-mixture of convertible components* in the language of that paper. Applied to the vapor of the peroxide of nitrogen, these equations led to a formula giving the density in terms of the temperature and pressure, which was shown to agree very closely with the experiments of Deville and Troost, and much less closely, but apparently within the limits of possible error, with the experiments of Playfair and Wanklyn. Since the publication of that paper, new determinations of the density have been published in different quarters, which render it possible to compare the equation with the results of experiment throughout a wider range of temperature and pressure. In the present paper, all experimental determinations of the density of this vapor which have come to the knowledge of the writer are cited, and compared with the values demanded by the formula, and a similar comparison of theory and experiment is made with respect to each of the other substances which have been mentioned.

The considerations from which these formulæ were deduced may be briefly stated as follows. It will be observed that they are based rather upon an extension of generally acknowledged principles to a new class of cases than upon the introduction of any new principle.

The energy of a gas-mixture may be represented by an expression of the form

$$m_1(c_1 t + \mathrm{E}_1) + m_2(c_2 t + \mathrm{E}_2) + \text{etc.},$$

with as many terms as there are different kinds of gas in the mixture, m_1, m_2, etc., denoting the quantities (by weight) of the several component gases, c_1, c_2, etc., their several specific heats at constant volume, E_1, E_2, etc., other constants, and t the absolute temperature. In like manner the entropy of the gas-mixture is expressed by

$$m_1\left(\mathrm{H}_1 + c_1 \log_{\mathrm{N}} t - a_1 \log_{\mathrm{N}} \frac{m_1}{v}\right)$$
$$+ m_2\left(\mathrm{H}_2 + c_2 \log_{\mathrm{N}} t - a_2 \log_{\mathrm{N}} \frac{m_2}{v}\right) + \text{etc.},$$

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* "On the Equilibrium of Heterogeneous Substances." Transactions of the Connecticut Academy, vol. iii, p. 108. The equations referred to are (313), (317), (319) and (320), on pages 233 and 234. The applicability of these equations to such cases as we are now considering is discussed under the heading "Gas-mixtures with Convertible Components," page 234.

where v denotes the volume, and H_1, a_1, H_2, a_2, etc., denote constants relating to the component gases, a_1, a_2, etc., being inversely proportional to their several densities. The logarithms are Naperian. These expressions for energy and entropy will undoubtedly apply to mixtures of different gases, whatever their chemical relations may be, (with such limitations and with such a degree of approximation as belong to other laws of the gaseous state), when no chemical action can take place under the conditions considered. If we assume that they will apply to such cases as we are now considering, although chemical action is possible, and suppose the equilibrium of the mixture with respect to chemical change to be determined by the condition that its entropy has the greatest value consistent with its energy and its volume, we may easily obtain an equation between m_1, m_2, etc., t and v.*

The condition that the energy does not vary, gives

$$(m_1 c_1 + m_2 c_2 + \text{etc.})\,dt + (c_1 t + E_1)\,dm_1 + (c_2 t + E_2)\,dm_2 + \text{etc.} = 0. \qquad (1)$$

The condition that the entropy is a maximum implies that its variation vanishes, when the energy and volume are constant: this gives

$$\frac{m_1 c_1 + m_2 c_2 + \text{etc.}}{t}\,dt + \left(H_1 - a_1 + c_1 \log_N t - a_1 \log_N \frac{m_1}{v}\right) dm_1 + \left(H_2 - a_2 + c_2 \log_N t - a_2 \log_N \frac{m_2}{v}\right) dm_2 + \text{etc.} = 0. \qquad (2)$$

Eliminating dt, we have

$$\left(H_1 - a_1 - c_1 - \frac{E_1}{t} + c_1 \log_N t - a_1 \log_N \frac{m_1}{v}\right) dm_1 + \left(H_2 - a_2 - c_2 - \frac{E_2}{t} + c_2 \log_N t - a_2 \log_N \frac{m_2}{v}\right) dm_2 + \text{etc.} = 0. \qquad (3)$$

If the case is like that of the peroxide of nitrogen, this equation will have two terms, of which the second may refer to the denser component of the gas-mixture. We shall then have $a_1 = 2a_2$, and $dm_1 = - dm_2$, and the equation will reduce to the form

$$\log \frac{m_2 v}{m_1^2} = - A - B \log t + \frac{C}{t}, \qquad (4)$$

where common logarithms have been substituted for Naperian, and A, B and C are constants. If, in place of the quantities of the components, we introduce the partial pressures, p_1, p_2, due to these components, and measured in millimeters of mercury, by means of the relations

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* For certain *a priori* considerations which give a degree of probability to these assumptions, the reader is referred to the paper already cited.

$$m_1 = \frac{p_1 v}{\alpha_1 t}, \qquad m_2 = \frac{p_2 v}{\frac{1}{2}\alpha_1 t},$$

where α_1 denotes a constant, we have

$$\begin{aligned} \log \frac{p_2}{p_1^2} &= -(\mathrm{A} + \log 2\,\alpha_1) - (1 + \mathrm{B}) \log t + \frac{\mathrm{C}}{t} \\ &= -\mathrm{A}' - \mathrm{B}' \log t + \frac{\mathrm{C}}{t}, \end{aligned} \qquad (5)$$

where A′ and B′ are new constants. Now if we denote by p the total pressure of the gas-mixture (in millimeters of mercury), by D its density (relative to air of the same temperature and pressure), and by D_1 the theoretical density of the rarer component, we shall have

$$p : p + p_2 :: \mathrm{D}_1 : \mathrm{D}.$$

This appears from the consideration that $p+p_2$ represents what the pressure would become, if without change of temperature or volume all the matter in the gas-mixture could take the form of the rarer component. Hence,

$$p_2 = p\,\frac{\mathrm{D} - \mathrm{D}_1}{\mathrm{D}_1},$$

$$p_1 = p - p_2 = p\,\frac{2\,\mathrm{D}_1 - \mathrm{D}}{\mathrm{D}_1},$$

and

$$\frac{p_2}{p_1^2} = \frac{\mathrm{D}_1 (\mathrm{D} - \mathrm{D}_1)}{p\,(2\,\mathrm{D}_1 - \mathrm{D})^2}.$$

By substitution in (5) we obtain

$$\log \frac{\mathrm{D}_1 (\mathrm{D} - \mathrm{D}_1)}{(2\,\mathrm{D}_1 - \mathrm{D})^2} = -\mathrm{A}' - \mathrm{B}' \log t + \frac{\mathrm{C}}{t} + \log p_1. \qquad (6)$$

By this formula, when the values of the constants are determined, we may calculate the density of the gas-mixture from its temperature and pressure. The value of D_1 may be obtained from the molecular formula of the rarer component. If we compare equations (3), (4) and (5), we see that

$$\mathrm{B}' = \mathrm{B} + 1, \qquad \mathrm{B} = \frac{c_1 - c_2}{a_2}.$$

Now $c_1 - c_2$ is the difference of the specific heats at constant volume of NO_2 and N_2O_4. The general rule that the specific heat of a gas at constant volume and per unit of weight is independent of its *condensation*, would make $c_1 = c_2$, $\mathrm{B} = 0$, and $\mathrm{B}' = 1$. It may easily be shown, with respect to any of the substances considered in this paper,* that unless the numerical value of B′ greatly exceeds unity, the term B′ log t may be neglected without serious error, if its omission is compensated in the values given to A′ and C. We may therefore cancel this term, and then determine the remaining constants by comparison of the formula with the results of experiment.

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* For the case of peroxide of nitrogen, see pp. 243, 244 in the paper cited above.

In the case of a mixture of Cl_2, PCl_3 and PCl_5, equation (3) will have three terms distinguished by different suffixes. To fix our ideas, we may make these suffixes $_2$, $_3$ and $_5$, referring to Cl_2, PCl_3 and PCl_5 respectively. Since the constants a_2, a_3 and a_5 are inversely proportional to the densities of these gases,

$$a_2\, dm_2 = a_3\, dm_3 = -\, a_5\, dm_5,$$

and we may substitute $\frac{1}{a_2}, \frac{1}{a_3}, \frac{-1}{a_5}$ for dm_2, dm_3 and dm_5 in equation (3), which is thus reduced to the form

$$\log \frac{m_5\, v}{m_2\, m_3} = -\mathrm{A} - \mathrm{B} \log t + \frac{\mathrm{C}}{t}. \tag{7}$$

If we eliminate m_2, m_3, m_5 by means of the partial pressures, p_2, p_3, p_5, we obtain

$$\log \frac{p_5}{4 p_2 p_3} = -\mathrm{A}' - \mathrm{B}' \log t + \frac{\mathrm{C}}{t}, \tag{8}$$

when A′, B′, like A, B and C, are constants. If the chlorine and the protochloride are in such proportions as arise from the decomposition of the perchloride, $p_2 = p_3$ and $4p_2p_3 = (p_2 +_3)^2$. In this case, therefore, we have

$$\log \frac{p_5}{(p_2 + p_3)^2} = -\mathrm{A}' - \mathrm{B}' \log t + \frac{\mathrm{C}}{t}. \tag{9}$$

It will be seen that this equation is of the same form as equation (5), when p_5 in (9) is regarded as corresponding to p_2 in (5), and $p_2 + p_3$ in (9), which represents the pressure due to the products of decomposition, is regarded as corresponding to p_1 in (5), which has the same signification. It follows that equation (5), as well as (6), which is derived from it, may be regarded as applying to the vapor of perchloride of phosphorus, when the values of the constants are properly determined. This result might have been anticipated, but the longer course which we have taken has given us the more general equations, (7) and (8), which will apply to cases in which there is an excess of chlorine or of the protochloride.

If the gas-mixture considered, in addition to the components capable of chemical action, contains a neutral gas, the expressions for the energy and entropy of the gas-mixture should properly each contain a term relating to this neutral gas. This would make it necessary to add $c_n m_n$ to the coefficient of dt in (1), and $\frac{c_n m_n}{t}$ to the coefficient of dt in (2), the suffix $_n$ being used to mark the quantities relating to the neutral gas. But these quantities would disappear with the elimination of *dt*, and equation (3) and all the subsequent equations would require no modification, if only *p* and D are estimated (in accordance with usage) with exclusion of the pressure and weight due to the neutral gas. This result, which may be extended to any number of neutral gases, is simply an expression of Dalton's Law.

We now proceed to the comparison of the formulæ, especially of equation (6), with the results of experiment.

TABLE I.—PEROXIDE OF NITROGEN.

Experiments at Atmospheric Pressure.

MITSCHERLICH,—R. MÜLLER—DEVILLE and TROOST.

Temper-ature.	Press-ure.	Density calc. by eq. (10).	Density observed.				Excess of observed density.			
				Deville & Troost.				Deville & Troost.		
			M—h. M—r.	I.	II.	III.	M—h, M—r.	I.	II.	III.
183·2	(760)	1·592				1·57				—·022
154·0	(760)	1·597				1·58				—·017
151·8	(760)	1·598		1·50				—·10		
135·0	(760)	1·607				1·60				—·007
121·8	(760)	1·622		1·64				+·02		
121·5	(760)	1·622				1·62				—·002
111·3	(760)	1·641				1·65				+·009
100·25	760	1·677	1·72				+·04			
100·1	(760)	1·676				1·68				+·004
100·0	(760)	1·677		1·71				+·03		
90·0	(760)	1·728				1·72				—·008
84·4	(760)	1·768		1·83				+·06		
80·6	(760)	1·801				1·80				—·001
79	748	1·814	1·84				+·03			
77·4	(760)	1·833			1·85				+·02	
70·0	(760)	1·920				1·92				·000
70	754·5	1·919	1·95				+·03			
68·8	(760)	1·937		1·99				+·05		
66·0	(760)	1·976			2·03				+·05	
60·2	(760)	2·067				2·08				+·013
55·0	(760)	2·157			2·20				+·04	
52	757	2·211	2·26				+·05			
49·7	(760)	2·255		2·34				+·09		
49·6	(760)	2·256				2·27				+·014
45·1	(760)	2·342			2·40				+·06	
39·8	(760)	2·443				2·46				+·017
35·4	(760)	2·524				2·53				+·006
35·2	(760)	2·528		2·66				+·13		
34·6	(760)	2·539			2·62				+·08	
32	748	2·582	2·65				+·07			
28·7	(760)	2·642		2·80				+·16		
28	751	2·652	2·70				+·05			
27·6	(760)	2·661			2·70				+·04	
26·7	(760)	2·676				2·65				—·026

Peroxide of nitrogen.—If we take the constants of the equation for this substance from the paper already cited,* we have

$$\log \frac{15{\cdot}89\,(D - 1{\cdot}589)}{(3{\cdot}178 - D)^2} = \frac{3118{\cdot}6}{t_C + 273} + \log p - 12{\cdot}451, \qquad (10)$$

t_C denoting the temperature on the centigrade scale. The numbers 3·178 and 1·589 represent the theoretical densities of N_2O_4 and NO_2 respectively. The two other constants were determined by the experiments of Deville and Troost.

The results of these and other experiments at atmospheric pressure, all made by Dumas' method, are exhibited in Table I. The first three columns give the temperature (centigrade), the pressure (in millimeters of mercury),† and the density calculated from the temperature and pressure by equation (10). The subsequent columns give the densities observed by different authorities, and the excess of the observed over the calculated densities. In the first column of observed densities, we have one observation by Mitscherlich‡ (at 100·25°) and five by R. Müller.§ The three remaining columns contain each the results of a series of experiments by Deville and Troost.‖ In each series the experiments were made with increasing temperatures, and with the same vessel, without refilling. It should be observed that the results of the three series are not regarded by their distinguished authors as of equal weight. It is expressly stated that the numbers in the two earlier series, and especially in the first, may be less exact. The last series agrees very closely with the formula. It was from this that the constants of the formula were determined. The experiments of series I and II, and those of Mitscherlich and Müller, give somewhat larger values, with a single exception, as is best seen in the columns which give the excess of the observed density. The differences between the different columns are far too regular to be attributed to the accidental errors of the individual observations, except in the case of the experiment at 151·8°, where some accident has evidently occurred either in the experiment itself or in the reduction of the result. Setting this observation aside, we must look for some constant cause for the other discrepancies between the different series.

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* See equation (336) on page 339, *loc. cit.*,—also the following equations in which the density is given in terms of the temperature and pressure. In comparing these equations, it must be observed that in (336) the pressures are measured in atmospheres, but in this paper in millimeters of mercury.

† 760^{mm} has been assumed as the pressure of the atmosphere in all cases in which the precise pressure is not recorded in the published account of the experiments. The figures inserted in the columns of pressures are in such cases enclosed in parentheses. The same course has been followed in the subsequent tables. With respect to the principal series of observations by Deville and Troost (series III), it is stated that the barometer varied between 747 and 764 millimeters. A difference of 13 millimeters in the pressure would in no case cause a difference of ·005 in the calculated densities. In this series, therefore, the errors due to this circumstance are not very serious.

‡ Pogg. Ann., vol. xxix (1833), p. 220.

§ Lieb. Ann., vol. cxxii (1862), p. 15.

‖ Comptes Rendus, vol. lxiv (1867), p. 237.

We can hardly attribute these discrepancies to difference in the material employed, or to air or other foreign substance imperfectly expelled from the flask. For impurities which increase the density would make the divergence between the different series greatest when the densities are the least, whereas the divergences seem to vanish as the density approaches the limiting value. (A similar objection would apply to the supposition of any error in the determination of the weight of the flask when filled with air alone.) But if we should attribute the divergences to an impurity which diminishes the density (as air), we should be driven to the conclusion that the first series of Deville and Troost gives the most correct results, and that all the best attested numbers at temperatures below 90° are considerably in the wrong. It does not seem possible to account for these discrepancies by any causes which would apply to cases of normal or constant density. They are illustrations of the general fact that when the density varies rapidly with the temperature, determinations of density for the same temperature and pressure by different observers, or different determinations by the same observer, exhibit discordances which are entirely of a different order of magnitude from those which occur with substances of normal or constant densities, or which occur with the same substance at temperatures at which the density approaches a constant value. In some cases such results may be accounted for by carelessness on the part of the observers, not controlled by a comparison of the result with a value already known. But such an explanation is inadequate to explain the general fact, and evidently inadmissible in the present case.

It is probable that these discrepancies are in part attributable to a circumstance which has been noticed by M. Wurtz, in his account of his experiments upon the vapor-density of bromhydrate of amylene, in the following words: "Le temps pendant lequel la vapeur est maintenue à la température où l'on détermine la densité n'est pas sans influence sur les nombres obtenus. C'est ce qui résult des deux expériences faites à 225 degrés avec des produits identiques. Dans la première, la vapeur a été portée rapidement à 225 degrés. Dans la seconde elle a été maintenue pendant dix minutes à cette température. On voit que les nombres trouvés pour les densités ont été fort différents. [The numbers were 4·69 and 3·68 respectively.] Ce résultat ne doit point surprendre si l'on considère que le phénomène de décomposition de la vapeur doit absorber de la chaleur, et que les quantités de chaleur nécessaires pour produire et la dilatation et la décomposition ne sauraient être fournies instantanément."*

It is not difficult to form an estimate of the quantities of heat which come into play in such cases. With respect to peroxide of nitrogen, it was estimated in the paper already cited that the heat absorbed in the conversion of a unit of N_2O_4 into NO_2 under constant pressure is represented by 7181 a_2. (The heat is supposed to be measured in units of mechanical work). Now the external work done by the conversion of a unit of N_2O_4 into NO_2 under constant pressure is $a_2 t$. Therefore, the ratio of the heat absorbed to the external work done by the conversion of N_2O_4 into NO_2 is $7181 \div t$, or 23 at the temperature of 40° centigrade. Let us next consider how much more rapidly this vapor expands with increase of temperature at constant pressure than air. From the necessary relation

$$v=\frac{k\,m\,t}{p\,\mathrm{D}},$$

where m denotes the weight of the vapor, and k a constant, we obtain

$$\left(\frac{dv}{dt}\right)_p=\frac{v}{t}-\frac{v}{\mathrm{D}}\left(\frac{d\mathrm{D}}{dt}\right)_p,$$

where the suffix $_p$ indicates that the differential coefficients are for constant pressure. The last term of this expression evidently denotes the part of the expansion which is due to the conversion of N_2O_4 into NO_2, and the preceding term the expansion which would take place if there were no such conversion, and which is identical with the expansion of the same volume of air under the same circumstances. The ratio of the two terms is $-\frac{t}{\mathrm{D}}\left(\frac{d\mathrm{D}}{dt}\right)_p$, the numerical value of which for the temperature of 40° is 2·42, as may be found by differentiating equation (10), or, with less precision, from the numbers in the third column of Table I. Let us now suppose that equal volumes of peroxide of nitrogen and of air at the temperature of ? 40° and the pressure of one atmosphere receive equal infinitesimal increments of temperature under constant pressure. The heat absorbed by the peroxide of nitrogen on account of the conversion of N_2O_4 into NO_2 is 23 times the external work due to the same cause, and this work is 2·42 times the external work done by the expansion of the air. But the heat absorbed by the air in expanding under constant pressure is well known to be 3·5 times the work done. Therefore the heat absorbed on account of the conversion of N_2O_4 into NO_2 is $(23\times 2{\cdot}42\div 3{\cdot}5=)15{\cdot}9$ times the heat absorbed by the air. To obtain the whole heat absorbed by the vapor we must add that which would be required if no conversion took place. At 40° the vapor of peroxide of nitrogen contains about 54 molecules of N_2O_4 to 46 of NO_2, as may easily be calculated from its density. The specific heat for constant pressure of a mixture in such proportions of gases of such molecular formulæ, if no chemical action could take place, would be about twice that of the same volume of air. Adding this to the heat absorbed by the chemical action we obtain the final result,—that at 40° and the pressure of the atmosphere the specific heat of peroxide of nitrogen at constant pressure is about eighteen times that of the same volume of air.*

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* Comptes Rendus, t. lx, p. 730.

But the greater amount of heat which is required to bring the vapor to the desired temperature is only one factor in the increased liability to error in cases of this kind. The expansion of peroxide of nitrogen for increase of temperature under constant pressure at 40° is 3·42 times that of air. If then, in a determination of density, the vapor fails to reach the temperature of the bath, the error due to the difference of the temperature of the vapor and the bath, will be 3·42 times as great as would be caused by the same difference of temperatures in the case of any vapor or gas having a constant density. When we consider that we are liable not only to the same, but to a much greater difference of temperatures in a case like that of peroxide of nitrogen, when the exposure to the heat is of the same duration, it is evident that the common test of the exactness of a process for the determination of vapor-densities, by applying it to a case in which the density is nearly constant, is entirely insufficient.

That the experiments of the III^d series of Deville and Troost give numbers so regular and so much lower than the other experiments is probably to be attributed in part to the length of time of exposure to the heat of the experiment, which was half an hour in this series,—for the other series, the time is not given.

Another point should be considered in this connection. During the heating of the vapor in the bath, it is not immaterial whether the flask is open or closed. This will appear, if we compare the values of $\left(\frac{dD}{dt}\right)_p$ and $\left(\frac{dD}{dt}\right)_v$, the differential coefficients of the density with respect to the temperature on the suppositions, respectively, of constant pressure, and of constant volume. For 40°, we have

$$\left(\frac{dD}{dt}\right)_p = \cdot 0189, \qquad \left(\frac{dD}{dt}\right)_v = \cdot 0163,$$

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* Similar calculations from less precise data for the bromhydrate of amylene at 225° seem to indicate a specific heat as much as forty times as great as that of the same volume of air.

the first number being obtained immediately from equation (10) by differentiation, and the second by differentiation after substitution of $\frac{kmt}{vD}$ for p. The ratio of these numbers evidently gives the proportion in which the chemical change takes place under the two suppositions. This shows that only about six-sevenths of the heat required for the chemical change can be supplied before opening the flask, and the remainder of this heat as well as that required for expansion must be supplied after the opening. The errors due to this source may evidently be diminished by diminishing the intervals of temperature between the successive experiments in a series of this kind, and also by diminishing the opening made in the flask, which increases the time for which the flask may be left open without danger of the entrance of air. In the III^d series of experiments by Deville and Troost, the intervals of temperature did not exceed ten degrees (except after the density had nearly reached its limiting value), and the neck of the flask was drawn out into a very fine tube.

In Table II, which relates to experiments on the same substance at pressures less than that of the atmosphere, the principal series is that of Naumann,* which commences a few degrees below the lowest temperatures of Deville and Troost, and extends to $-6°$ centigrade, the pressures varying from 301 to 84 millimeters. These experiments were made by the method of Gay-Lussac. The numbers in the column of observed densities have been re-calculated from the more immediate results of the experiments, and are not in all cases identical with those given in Professor Naumann's paper. Every case of difference is marked with brackets. Instead of the numbers [2·66], [2·62], [2·85], [2·94], Naumann's paper has 2·57, 2·65, 2·84, 3·01, respectively. In some cases the temperatures and pressures of two experiments are so nearly the same that it would be allowable to average the results, at least in the column of excess of observed density. In such cases the numbers in this column have been united by a brace. The greatest difference between the observed and calculated densities is ·16, which occurs at the least pressure, 84 millimeters. In this experiment the weight of the substance employed is also less than in any other experiment. Under such circumstances, the liability to error is of course greatly increased. The average difference between the observed and calculated densities is ·063. Since these differences are almost uniformly positive and increase as the temperature diminishes, it is evident that they might be considerably diminished by slight changes in the constants of equation (10), without seriously impairing the agreement of that equation with the experiments of Deville and Troost. But it has not seemed necessary to re-calculate the formula, which, in its present form, will at least illustrate the degree of accuracy with which densities at low pressures and at temperatures below the boiling point of the liquid may be derived from experiments at atmospheric pressure above the boiling point. Moreover, the excess of observed density may be due in part to a circumstance mentioned by Professor Naumann, that the chemical action between the vapor and the mercury diminished the volume of the vapor, and thus increased the numbers obtained for the density.

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* Berichte der Deutschen Chemischen Gesellschaft, Jahrgang xi (1878), S. 2045.

TABLE II.—PEROXIDE OF NITROGEN.

Experiments at less than Atmospheric Pressure.

PLAYFAIR and WANKLYN,—TROOST,—NAUMANN.

Temperature.	Pressure.	Density calculated by eq. (10).	Density observed.			Excess of obs. density.		
			P. & W.	T.	N.	P. & W.	T.	N.
97·5	(301)	1·631	1·783			+·152		
27	35	1·90		1·6			—·30	
27	16	1·77		1·59			—·18	
24·5	(323)	2·524	2·52			—·004		
22·5	136·5	2·34			2·35			+·01
22·5	101	2·26			2·28			+·02
21·5	161	2·41			2·38			—·03
20·8	153·5	2·41			2·46			+·05
20	301	2·59			2·70			+·11
18·5	136	2·43			2·45			+·02
18	279	2·61			2·71			+·10
17·5	172	2·51			2·52			+·01
16·8	172	2·53			2·55			+·02
16·5	224	2·59			[2·66]			+·07
16	228·5	2·61			[2·62]			+·01
14·5	175	2·58			2·63			+·05
11·3	(159)	2·620	2·645			+·025		
11	190	2·66			2·76			+·10
10·5	163	2·64			2·73			+·09
4·2	(129)	2·710	2·588			—·122		
4	172·5	2·77			2·85			+·08
2·5	145	2·76			[2·85]			+·09
1	138	2·78			2·84			+·06
—1	153	2·83			2·87			+·04
—3	84	2·76			2·92			+·16
—5	123	2·85			2·98			+·13
—6	125·5	2·87			[2·94]			+·07

The same table includes two experiments of Troost,* by Dumas' method, but at the very low pressures of 35^{mm} and 16^{mm}. In such experiments we cannot expect a close agreement with the formula, for the same error in the determination of the weight of the vapor, which would make a difference of

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* Comptes Rendus, t. lxxxvi (1878), p. 1395.

·01 in the density in experiments at atmospheric pressure, would make a difference of ·21 or ·47 in the circumstances of these experiments. In fact, the numbers obtained differ considerably from those demanded by the formula.

There remain four experiments by Playfair and Wanklyn* in which Dumas' method was varied by diluting the vapor with nitrogen. The numbers in the column of pressures represent the total pressure diminished by the pressure which the nitrogen alone would have exerted. They are not quite accurate, since the data given to the memoir cited only enable us to determine the ratios of the total and the partial pressures. The numbers here given are obtained by setting the total pressure, which was that of the atmosphere at the time of the experiment, equal to 760^{mm}. The effect of this inaccuracy upon the calculated densities would be small. Two of these observations agree closely with the formula; and two show considerable divergence, but in opposite directions, and these are the two in which the quantities of peroxide of nitrogen were the smallest. The differences appear to be attributable rather to the difficulty of a precise determination of the quantities of nitrogen and of vapor, than to any effect of the one upon the other.

Special interest attaches to experiments at the same or nearly the same temperature but different pressures. For with experiments at the same temperature, the constants of the formula which are determined by observation are reduced to one, so that the verification of the formula by experiment cannot possibly be regarded as a case of interpolation. It is not necessary that the temperatures should be exactly the same, for it will be conceded that the formula represents the actual function well enough to answer for adjusting slight differences of temperature; but it is necessary that the range of pressures should be considerable in order that the differences of density should be large in proportion to the probable errors of observation. But the pressures must not be so low that accurate determinations become impossible.

In the experiments of Naumann we see some fair correspondences with the formula in respect to the influence of pressure, especially in the first four experiments of the list, where, if we average the results of the third and fourth experiments, as is evidently allowable, the observed values follow very closely the fluctuations of the calculated, extending from 2·26 to 2·41. In other cases the agreement is less satisfactory. The circumstance that the experiments at the two highest pressures (301 and 279^{mm}), give results exceeding the calculated values considerably more than any other experiments at adjacent temperatures may seem to indicate that the densities increase with the pressures more rapidly than the formula allows; but the differences are not too large to be ascribed to errors of observation, and the experiment at the lowest pressure (84^{mm}) also shows a large excess of observed density.

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* Trans. Roy. Soc. Edinb., vol. xxii (1861), p. 463.

A much more critical test may be found in the comparison of Naumann's experiments with those of Deville and Troost, notwithstanding the interval of about 4° of temperature. The formula requires that a diminution of pressure from 760 to 101 millimeters shall reduce the density from 2·676 at 26·7° to 2·26 at 22·5, notwithstanding the effect of the change of temperature. Experiment gives a reduction of density from 2·65 to 2·28, which is about one-ninth less. This is, it will be observed, a deviation from the formula in the opposite direction from that which the experiments of Naumann alone, or a comparison of the experiments of Troost with those of Deville and Troost, seemed to indicate. The experiment here compared with Naumann's belongs to the III^d series of Deville and Troost. If instead of this experiment we should take an average of the experiments at lowest temperature in the II^d and III^d series, the agreement with the formula with respect to the effect of change of pressure would be almost perfect.

Formic acid.—In Table III, the determinations of Bineau are compared with the densities calculated by the formula

$$\log \frac{1{\cdot}589\,(D - 1{\cdot}589)}{(3{\cdot}178 - D)^2} = \frac{3800}{t_C + 273} + \log p - 12{\cdot}641. \qquad (11)$$

The observed densities are taken from the eighteenth volume of the third series of the Annales de Chimie et de Physique (1846), except in three cases, distinguished by parentheses, which are earlier determinations published in the nineteenth volume of the Comptes Rendus (1844). It may be added that the pressure (687) for the experiment at 108° is taken from Erdmann's Journal für praktische Chemie (vol. xl, p. 44), the impression being imperfect in the Annales, in the copies to which the writer has been able to refer, where the figures look much like 637. (The pressure 637 would make the calculated density 2·28.)

In the column which gives the excess of observed densities, the effect of nearness to the state of saturation is often very marked. Such cases are distinguished by an asterisk. The temperature of 99·5° is below the boiling point of formic acid, and the higher pressures employed at this temperature cannot be far from the pressure of saturated vapor. With respect to lower temperatures, we have the statement of Bineau that the pressure of saturated vapor is about 19^{mm} at 13°, $20{\cdot}5^{mm}$ at 15°, $33{\cdot}5^{mm}$ at 22°, and $53{\cdot}5^{mm}$ at 32°. By interpolation between the *logarithms* of these pressures, (in a single case, by *extrapolation*), we obtain the following result.

Temperature............	10·5	12·5	16	18·5	22
Pressure of sat. vapor...	16·6	18·5	22	26·2	33·5
Pressure of experiment..	14·69	15·20	15·97	23·53	25·17

TABLE III.—FORMIC ACID.

Experiments of BINEAU.

Temperature.	Pressure.	Density calculated by eq. (11).	Density observed.	Excess of observed density.
216·0	690	1·60	1·61	+·01
184·0	750	1·64	1·68	+·04
125·5	687	2·03	2·05	+·02
125·5	645	2·02	2·03	+·01
124·5	670	2·04	2·06	+·02
124·5	640	2·03	2·04	+·01
118·0	655	2·13	(2·14)	(+·01)
118·0	650	2·13	2·13	·00
117·5	688	2·15	2·13	—·02
115·5	649	2·17	2·20	+·03
115·5	640	2·16	2·16	·00
115	655	2·18	(2·13)	(—·05)
111·5	690	2·25	2·22	—·03
111·5	690	2·25	2·25	·00
111	608	2·22	(2·13)	(—·09)
108	[687]	2·30	2·31	+·01
105·0	691	2·35	2·35	·00
105·0	650	2·34	2·33	—·01
105·0	630	2·33	2·32	—·01
101·0	693	2·42	2·44	+·02
101·0	650	2·40	2·41	+·01
99·5	690	2·44	2·52	+·08*
99·5	684	2·44	2·49	+·05
99·5	676	2·44	2·46	+·02
99·5	662	2·43	2·44	+·01
99·5	641	2·42	2·42	·00
99·5	619	2·41	2·41	·00
99·5	602	2·41	2·40	—·01
99·5	557	2·39	2·34	—·05
34·5	28·94	2·82	2·77	—·05
31·5	3·04	2·40	2·60	+·20
30·5	8·83	2·67	2·69	+·02
30·0	18·28	2·81	2·76	—·05
29·0	27·40	2·88	2·83	—·05
24·5	17·39	2·88	2·86	—·02
22·0	25·17	2·95	3·05	+·10*
20·0	16·67	2·93	2·94	+·01
20·0	7·99	2·84	2·85	+·01
20·0	2·72	2·64	2·80	+·16
18·5	23·53	2·98	3·23	+·25*
16·0	15·97	2·97	3·13	+·16*
15·5	2·61	2·72	2·86	+·14
15·0	7·60	2·90	2·93	+·03
12·5	15·20	3·00	3·14	+·14*
11·0	7·26	2·95	3·02	+·07
10·5	14·69	3·01	3·23	+·22*

Whether the large excess of observed density in these cases represents a property of the vapor, or an incipient condensation on the walls of the vessel which contains it, as has been supposed by eminent physicists in similar cases, we need not here discuss.

If we reject these cases of nearly saturated vapor, as well as the three earlier determinations, there remain 25 experiments at pressures somewhat less than one atmosphere in which the maximum difference between the observed and calculated densities is ·05, and the average difference ·016; nine experiments at pressures ranging from 29^{mm} to 7^{mm}, in which the maximum difference is ·07 and the average ·035; and three experiments at pressures of about 3^{mm}, in which the average difference is ·17. The extraordinary precision of the determinations at low pressures is doubtless due to the large scale on which the experiments were conducted. All the experiments at temperatures below 99°, were made with a globe of the capacity of 5½ liters with a stem of suitable length to hold the barometric column.

The agreement is certainly as good as could be desired, and shows the accuracy of which the method of observation is capable. But in no part of the thermometric scale do we find so great a range of pressures as might be desired, without using pressures too low for accurate results, or observations which are to be rejected for other reasons.

[To be continued.]

ART. XXXVIII.—*The Fault at Rondout;* by T. NELSON DALE, Jr.

MATHER gives a section,* from between Glasco and Great Falls of Esopus Creek, in which the Hudson River slates and the Lower Helderberg limestones are unconformably superposed, and the latter present the form of a ruptured and eroded anticlinal. He gives also, Plate 8, fig. 7, a rough and unsatisfactory section of "High Rock," situated opposite Rhinebeck, between the junction of the Wallkill and the Hudson. In this section the Lower Helderberg limestones are represented in an almost erect position, resting unconformably upon Hudson River grits.

Mr. J. G. Lindsley, the agent of the Cement Co. at Rondout, read an interesting paper† before the Poughkeepsie Society of Natural Science on Feb. 26, 1879, which contains the results of local studies for which he has had excellent opportunities.

In the summer of 1878, I made several hasty visits to the highly instructive locality at Rondout, and obtained the following data, some of which, as well as the inferences from them, are not given in Mr. Lindsley's paper. The southeast base of the hill consists of grit dipping east-northeast at an angle of about 45°. These grits form part of the series of clay-slates and grits of the Hudson River group.* Unconformably resting upon these grits is a series of limestones, dipping at about the same angle, but toward the northwest. The grits are non-fossiliferous at this point. The limestones are abundantly fossiliferous. I am indebted to Mr. Lindsley for the following measurements of the latter.

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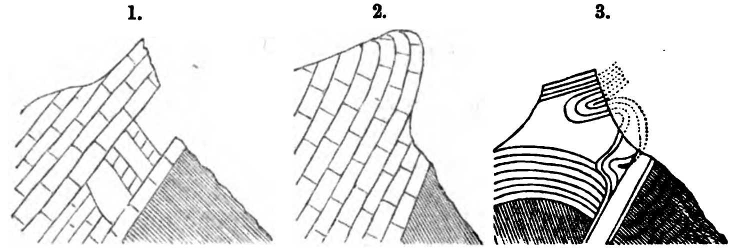
* Nat. Hist. of N. Y., Part IV, Geology, by W. W. Mather. Pl. 7, fig. 9, 1843.

† "A Study of the Rocks," by James G. Lindsley, in the forthcoming Part I, vol. ii, of Proceedings of the Poughkeepsie Society of Natural Science.

Beginning above: No. 9, 20 feet or more, Upper Pentamerus limestone. No. 8, 20 feet, Encrinal limestone. No. 7, 15–20 feet, Delthyris limestone. No. 6, 20 feet Lower Pentamerus limestone with chert, *Pentamerus galeatus*, Crinoids. No. 5, 6 feet, Ribbon limestone with *Stromatopora concentrica*. No. 4, 15 feet, Tentaculite limestone with *Tentaculites irregularis*, *Leperditia alta*. No. 3, 4 feet, limestone with prismatic mud cracks. No. 2, 30 feet, Water-lime with *Leperditia alta*. No. 1, 6 feet, Encrinal limestone. Whatever may be thought as to the presence in No. 1 and 2 of Niagara beds, we certainly have to do with Lower Helderberg in part of No. 2 and in No. 3 and 4. The relative position of the rocks is shown in the accompanying sections. For Section No. 3, I am indebted to Mr. Lindsley. The excavations represented in figure 1 were made in quarrying, the rock being a hydraulic limestone or "cement rock."



Figs. 1 to 3. Lower Helderberg beds resting unconformably on the Hudson River group (fine-lined portion in the figures); in figs. 1 and 2, dip of L. H. northwest, of H. R. east-northeast.

It has been supposed, I believe by Sir William Logan, that the great fault which begins near Quebec, crosses the Hudson near Rhinebeck, and there separates the Quebec from the true Hudson River beds.† It would appear that this is erroneous and that the facts of the case at these localities are simply these. At the close of the Hudson River Period, the Lower Silurian beds were powerfully folded and metamorphosed. A period of uplift and erosion followed; then a depression and the deposition of the Upper Silurian series. At some later time, probably at the period of the Appalachian revolution, the whole series, i. e. the Hudson River and Lower Helderberg formations, were uplifted, folded, fractured, faulted and tilted.

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* See this Journal, III, vol. xvii, 1879, page 57, "On the Age of the Clay-slates and Grits of Poughkeepsie," by T. Nelson Dale. Jr.

† Dana, Manual of Geology, page 184, 2d edition, 1876.

The complicated stratification of Section 3, may perhaps be accounted for as follows. First, unconformable deposition of Lower Helderberg upon Hudson River beds; then the formation of an anticlinal, and at the same time, closely adjoining it, a treble fold. The folds by the continued pressure were broken off from the anticlinal and thrown into an erect position. The same force has also compressed the lowest fold between the edges of the anticlinal on one side, and the surface of other Lower Helderberg strata on the other. The uppermost layers of this fold were by this action ruptured. This is not shown in the cut. As the upper portion of the base of the hill has been quarried away, the segments of three folds are now in view, one above another. The thickness of the contorted strata has been much reduced by pressure.

ART. XXXIX.—*On the Chemical Composition of Amblygonite;*
by SAMUEL L. PENFIELD.

THE new mineral species triploidite described by Messrs. Brush and Dana* is shown by them to be isomorphous with wagnerite and closely related in composition to triplite. These three minerals have respectively the formulas $(Mn,Fe)_3 P_2O_8+(Mn,Fe)(OH)_2$, $Mg_3 P_2O_8+MgF_2$ and $(Fe,Mn)_3 P_2O_8+(Fe,Mn) F_2$. From a comparison of these formulas it is argued (l. c., p. 45) that the relation between the minerals requires the assumption that the hydroxyl in triploidite must play the same part as the fluorine in the other two.

In this paper I wish to show that in amblygonite the hydroxyl group is also isomorphous with fluorine, and that in chemical composition the original amblygonite does not differ from the American and Montebras varieties which have been called hebronite. I shall also show that the results of my analyses require the adoption of a new formula for the mineral, more simple than that previously accepted. For analysis I have selected specimens from the three localities in Maine, from Branchville, Connecticut, where the mineral has been lately discovered by Messrs. Brush and Dana, also two varieties from Montebras and one from Penig, Saxony, from a specimen in the Yale College collection.

The analyses are arranged so as to form a series, beginning with the one which contains the smallest amount of water.

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* This Journal, III, xvi, 42, July, 1878.

I. *Penig, Saxony.*

	I.	II.	Mean.	Relative number of atoms.			
P_2O_5	48·35	48·13	48·24	P	·678		1·
Al_2O_3	33·50	33·60	33·55	Al	·651		·96
Li_2O	8·97	8·97	8·97	Li	·598	·664	·98
Na_2O	2·06	2·03	2·04	Na	·066		
Mn_2O_3	·12	·15	·13				
H_2O	1·75		1·75	OH	·194	·786	1·16
F	11·26		11·26	F	·592		
			105·94				
O equivalent of F			4·74				
			101·20				

II. *Montebras, France, variety A.* G.=3·088.

	I.	II.	Mean.	Relative number of atoms.			
P_2O_5	47·10	47·07	47·09	P	·664		1·
Al_2O_3	33·20	33·25	33·22	Al	·646		·97
Li_2O	7·93	7·90	7·92	Li	·528	·649	·98
Na_2O	3·48	....	3·48	Na	·112		
CaO	·25	·24	·24	Ca	·009		
H_2O	2·25	2·29	2·27	OH	·252	·775	1·17
F	10·00	9·86	9·93	F	·523		
			104·15				
O equivalent of F			4·02				
			100·13				

III. *Auburn, Maine.* G.=3·059.

	I.	II.	Mean.	Relative number of atoms.			
P_2O_5	48·56	48·40	48·48	P	·683		1·
Al_2O_3	33·67	33·90	33·78	Al	·656		·96
Li_2O	9·49	9·42	9·46	Li	·630	·662	·97
Na_2O	·96	1·02	·99	Na	·032		
H_2O	3·61	3·52	3·57	OH	·396	·722	1·06
F	6·26	6·15	6·20	F	·326		
			102·48				
O equivalent of F			2·61				
			99·87				

IV. *Hebron, Maine, variety A.*

			Relative number of atoms.			
P_2O_5	By difference	[48·53]	P	·682		1·
Al_2O_3		34·12	Al	·662		·97
Li_2O		9·54	Li	·636	·646	·95
Na_2O		·34	Na	·010		
H_2O		4·44	OH	·493	·769	1·13
F		5·24	F	·276		

This sample was accidentally lost before a phosphoric acid determination was made. It is inserted because it is regarded as a good analysis and it varies somewhat from the other sample from Hebron which was obtained to replace it.

V. *Paris, Maine.* G.=3·035.

	I.	II.	Mean.	Relative number of atoms.			
P_2O_5	48·28	48·35	48·31	P	·680		1·
Al_2O_3	33·87	33·50	33·68	Al	·654		·96
Li_2O	9·83	9·80	9·82	Li	·654	·664	·97
Na_2O	·43	·24	·34	Na	·010		
K_2O	·03	...	·03				
H_2O	4·96	4·82	4·89	OH	·543	·797	1·17
F	4·82	4·82	4·82	F	·254		
			101·89				
O equivalent of F			2·03				
			99·86				

VI. *Hebron, Maine, variety B.* G.=3·032.

	I.	II.	Mean.	Relative number of atoms.			
P_2O_5	47·44	47·44	47·44	P	·668		1·
Al_2O_3	33·79	34·01	33·90	Al	·658		·98
Li_2O	....	9·24	9·24	Li	·616	·638	·95
Na_2O	....	·66	·66	Na	·022		
H_2O	5·00	5·10	5·05	OH	·561	·848	1·27
F	5·53	5·36	5·45	F	·287		
			101·74				
O equivalent of F			2·29				
			99·45				

VII. *Branchville, Connecticut.* G.=3·032.

	I.	II.	Mean.	Relative number of atoms.			
P_2O_5	48·80	48·81	48·80	P	·686		1·
Al_2O_3		34·26	34·26	Al	·665		·97
Li_2O	9·69	9·90	9·80	Li	·653	·659	·96
Na_2O	·15	·24	·19	Na	·006		
Fe_2O_3	·29	·29	·29				
Mn_2O_3	·10	·10	·10				
H_2O	5·93	5·90	5·91	OH	·658	·750	1·09
F	1·75	1·75	1·75	F	·092		
			101·10				
O equivalent of F			·74				
			100·36				

VIII. *Montebras, France, variety B.* G.=3·007.

	I.	II.	Mean.	Relative number of atoms.			
P_2O_5	48·31	48·38	48·34	P	·681		1·
Al_2O_3	33·73	33·38	33·55	Al	·651		·96
Li_2O	9·53	9·50	9·52	Li	·634	·654	·96
Na_2O	·34	·33	·33	Na	·010		
CaO	·40	·30	·35	Ca	·010		
H_2O	6·61	6·61	6·61	OH	·734	·826	1·21
F	1·76	1·74	1·75	F	·092		
			100·45				
O equivalent of F			·74				
			99·71				

For more easy comparison the ratios from the above analyses are collected in the following table by themselves, where $\overset{\text{I}}{R}$ equals Li and Na.

		P	Al	$\overset{\text{I}}{R}$	(OH, F)
I.	Penig, Saxony	1·00	·96	·98	1·16
II.	Montebras, France, A	1·00	·97	·98	1·17
III.	Auburn, Maine	1·00	·96	·97	1·06
IV.	Hebron, Maine, A	1·00	·97	·95	1·13
V.	Paris, Maine	1·00	·96	·97	1·17
VI.	Hebron, Maine, B	1·00	·98	·95	1·27
VII.	Branchville, Conn.	1·00	·97	·96	1·09
VIII.	Montebras, France, B	1·00	·96	·96	1·21

It will be seen that all of these approach closely to the ratio 1 : 1 : 1 : 1, hence I propose the formula $Al_2P_2O_8+2R\,(OH, F)$ or $\left.\begin{matrix}3Al_2P_2O_8\\2R_3PO_4\end{matrix}\right\} + \left\{\begin{matrix}Al_2\,(OH, F)_6\\2R\,(OH, F)\end{matrix}\right.$ as the true formula for all varieties of this mineral.

DesCloizeaux, from a difference in optical characters made out by him, has divided the mineral into two species: the original amblygonite, including I and II in the above list; and a second species for which he proposed the name *montebrasite* (hebronite of von Kobell), including analyses III to VIII above. The mineral from Branchville has not been examined optically and the material is very unfavorable for such an examination. Owing to the close identity in chemical composition it seems that a slight variation in optical properties is hardly sufficient ground for dividing the mineral into two species, but on the contrary I think that the old name amblygonite should be retained, and that all varieties should be included by it.

It will be seen in comparing the above ratios that in every case the ratio of P to (OH, F) is in excess of that of the Al to R. Two theories suggest themselves to account for this, the first of which seems the most plausible. First: most minerals which are ordinarily regarded as anhydrous contain a small amount of water, which is not calculated in the ratios, and which is not regarded as essential to the composition. Now if these minerals contain a small quantity of such accidental water, it will bring up the ratios very considerably, owing to the small molecular weight of water, and if the slight variation between P, Al and R be regarded as due to error of analysis the excess of (OH, F) would be easily accounted for. Second: if we regard the difference between P, Al and R as not due to error of analysis, and the fact that the variation in all is so constant suggests this, and regard enough of the water basic so that when added to the Al and R it will make the ratio with P equal 1 : 1 : 1, then the ratio of (OH, F) will be: Penig, 1·02;

Montebras, A, 1·06: Auburn, 0·91; Hebron, A, 0·99; Paris, 1·02; Hebron, B, 1·18; Branchville, 0·97; Montebras, B, 1·05. This relation seems rather striking, and although it is not as simple as we should like to have it, or perhaps as plausible as the first theory, yet it may possibly be the correct one. Whichever of these explanations is accepted, it will not materially alter the formula above made out for the minerals, the variation from which is too slight and not constant enough to be expressed by any different formula. It will be seen from analyses I and II that water is found in the Penig and Montebras varieties which have been regarded as anhydrous by some analysts. This may have been overlooked, and it is worth noting that in Plattner's Blowpipe Analysis the statement is made, of the Penig mineral, that water is expelled by heating in a closed tube. It will also be seen that these analyses differ from the older ones in that they are lower in alumina and higher in alkalies. I have thought it best to give my method of analysis in full, which may account for some of the variations.

Method of Analysis.

Water was determined by ignition with oxide of lead in a porcelain crucible; it is completely driven off only by strong ignition, and it was found necessary to fuse the contents of the crucible over the blast lamp before constant results could be obtained. Fluorine was determined by decomposing a mixture of the mineral and powdered quartz with sulphuric acid, converting the silicon fluoride formed into hydrofluosilicic acid, precipitating the hydrofluosilicic acid with potassium chloride and titrating the liberated hydrochloric acid with a standard alkali solution.* The varieties from Penig and Montebras are decomposed only by prolonged action of sulphuric acid. Phosphoric acid was determined by fusing the mineral with sodium carbonate, boiling out the fused mass with water and dilute nitric acid, nearly neutralizing the excess of acid with ammonia, precipitating with molybdic solution and then proceeding in the usual way.

To determine the bases, one gram was weighed into a large platinum crucible, mixed into a paste with from two to three cubic centimeters of sulphuric acid, and heated, with the crucible covered, over a low gas flame till not over a cubic centimeter of sulphuric acid remained. The contents of the crucible were then rinsed into a platinum evaporating dish and treated with a quantity of strong hydrochloric acid; after heating and concentrating a clear solution was obtained. The excess of acid being removed by evaporation, the contents of the dish were rinsed into a beaker, filtered where necessary, the undissolved portion after incinerating the filter paper was treated with hydrofluoric acid, then with a drop of sulphuric acid; the hydrofluoric acid expelled by evaporation and the solution added to the other solution of the bases. To obtain the bases as chlorides the sulphuric acid was precipitated from the solution with barium chloride, and the barium sulphate filtered off. The solution was then heated to boiling and a hot solution of barium hydroxide added; this precipitated all the phosphoric acid and part of the alumina. The solution contained all the lithia and most of the alumina which went into solution in the excess of barium hydroxide. After filtering and washing the precipitate it was dissolved in hydrochloric acid, the excess expelled by evaporation; the residue taken up in a few drops of hydrochloric acid and water and poured when hot into a boiling solution of sodium hydroxide and a little barium hydroxide in a platinum dish; this again precipitated all the phosphoric acid while the alumina went into solution in the alkaline hydroxides. After filtering, the filtrate was acidified with hydrochloric acid, the barium precipitated with sulphuric acid, and the alumina precipitated with ammonia. The alumina found at this point amounted usually to about one-half per cent. The insoluble barium phosphate containing also traces of iron, manganese, and calcium was dissolved in hydrochloric acid, the barium precipitated with sulphuric acid, filtered and the filtrate made alkaline with ammonia; this precipitated any iron, manganese or calcium as phosphate which was filtered off and examined separately. It was intended at this point to determine the phosphoric acid by direct precipitation with magnesia mixture, but the results coming out too low an examination of all the barium sulphate precipitates showed that a quantity of the phosphoric acid had been precipitated along with the barium sulphate. The first filtrate from the barium hydroxide precipitate contained, free from phosphoric acid, all the lithia, the larger part of the alumina, and the excess of barium. It was heated to boiling and ammonium carbonate added; this precipitated the barium and aluminium and left the lithia in solution. The precipitate was washed first by decantation, then with hot water on the filter pump; it was not considered free from lithia, however, as it is practically impossible to wash a large barium carbonate precipitate free from lithia. The filtrate was evaporated to dryness, the ammonia salts expelled by ignition, traces of barium separated a second or third time when necessary, evaporated to dryness again, lithia separated from soda and potash by means of absolute alcohol and ether, the lithia weighed as sulphate and the soda and potash as chlorides. The chlorides were tested carefully for potash by evaporating with excess of platinum chloride and taking up in alcohol. The precipitate produced by ammonium carbonate was dissolved in hydrochloric acid, the barium precipitated with sulphuric acid, filtered and alumina precipitated in the filtrate with ammonia, the precipitate was washed with hot water, ignited finally over the blast lamp to expel sulphuric acid and weighed as oxide. The filtrate from the alumina was regarded as containing a trace of lithia which had been retained by the barium carbonate precipitate, it was evaporated to dryness, the ammonia salts expelled by ignition, taken up in water, filtered into a weighed crucible, evaporated to dryness and weighed, the lithia found amounted to from one-quarter to one per cent.

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* See Remsen's American Chemical Journal, vol. i, No. 1.

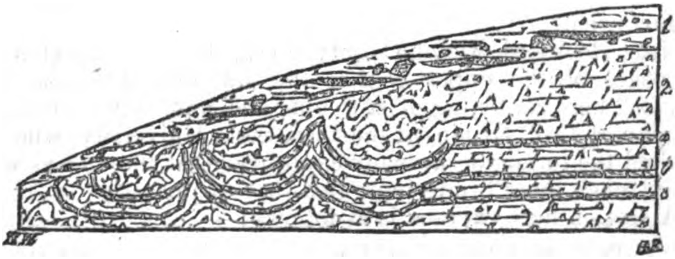
The solutions were kept as far as possible from all contact with glass, the evaporations being carried on in large platinum dishes. The reagents were carefully selected and purified. Sodium hydroxide free from aluminium and silica was obtained, prepared from metallic sodium. Owing to the limited amount of material from Penig only three-quarters of a gram was used in the determinations, and duplicates of the water and fluorine determination were not obtained. For the occurrence and associations of amblygonite at Branchville, Connecticut, see the papers by Messrs. Brush and Dana.*

In closing I wish to acknowledge my indebtedness to Professor Geo. J. Brush, who has most liberally furnished me with the material needed for this examination.

Sheffield Laboratory, June 18, 1879.

Art. XL.—*On the Superposition of Glacial Drift upon Residuary Clays*; by W. J. McGee.

The accompanying actual section is exposed in a cut on the Delaware & St. Paul Railroad, a mile north of Delaware, Delaware County, Iowa. No. 1 is glacial drift, somewhat light



and sandy, but containing erratics and continuous with the mantle of "ground moraine" deposits covering the greater portion of the State. A few fragments of chert from the underlying Niagara Limestone are scattered through the deposit. Its thickness in this section varies from one to three feet, but in the southeasterly end of the same cut it is considerably thicker. No. 2 is red clay with nodules of chert, but without sand or erratics. In no respect is it distinguishable from the residuary clays of the Wisconsin driftless region fifty miles to the eastward. Three unusually regular and uniform layers of chert are exposed, yet remaining *in situ* through the greater part of the length of the cut. They are represented at *a*, *b*, and *c*. To the northwesterly end of the cut, however, they are contorted as represented, evidently by glacial action. Still greater contortion is exhibited in the lines of original stratification which can occasionally be detected in the enveloping clay. These contortions must have strongly disturbed and corrugated the adjacent surfaces; but all trace of this was subsequently removed by the glacier.

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* This Journal, July and August, 1878, and May, 1879.

Though these members are so diverse in character, there is no well-defined plane of contact between them, nor is the surface of No. 2 in any place, so far as observed, smoothed or striated.

The direction of glacial motion here, as determined by the position of neighboring asar, was S. 50° or 55° E. The elevation of the section is 540 feet above the Mississippi at Dubuque.

Several analogous sections have been exposed in excavating wells two miles north of Farley, Dubuque County, Iowa, and in a cut on the Dubuque & Southwestern Railroad, half a mile southwest of the same place. Here, however, the drift is thicker and more compact than in the Delaware section, and contains a greater number of erratics; and many silicified Niagara fossils are found in the residuary clay, both free and imbedded in the nodules of chert. Aside from the thickness of the overlying beds of glacial drift we have here no positive evidence, such as is afforded by the Delaware section, that the residuary clay may not have been formed since the glacial period. Its surface has not been found to be either smoothed or furrowed.

Near Rockford, Floyd County, Iowa, there is an extensive exposure of the upper beds of the *Hamilton Limestone and Shales*,* here consisting of stiff blue and buff clays. It is the opinion of Prof. Calvin, of the Iowa State University, who has studied the formation at many exposures, that these clays were never much more firmly indurated than at present.

A section here exposed is as follows:—

1. Drift, with large bowlders,...............1 to 4 feet.
2. Clays of the Hamilton shales, about ....50 feet.

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* Sometimes denominated the *Rockford shales*. For the relations of the formation, with a description of some of its fossils, see Prof. S. Calvin's papers in this Journal, vol. xv, p. 460, and in Bull. Geol. and Geog. Surv. Terr., vol. iv, No. 3, p. 325.

The ice here moved S. 20° or 30° E., and must have been of immense thickness, as attested by the presence of northern bowlders 20 to 40 feet in diameter within a few miles to the leeward; yet the subjacent clays were not seriously disturbed, as evidenced by numerous absolutely perfect fossil Devonian brachiopods in the clay. The ice, too, must have ascended obliquely the steep slope of the bluff. A ground and striated specimen of *Orthis Vanuxemi*, and an *O. Iowensis* with a smoothed plane surface on the dorsal valve picked up from the talus at the base of the section, would indicate that the surface of the clays might exhibit glaciation on fresh exposure. At the time of examination the section was much weathered.

In none of these sections, nor in any of the many others which might be given, did space permit, are the pre-glacial clays more compact than is the lower till or blue clay found immediately below the latest formed glacial drift over the greater part of the State. It is this later drift which overlies the residuary and sedimentary clays in every instance.

The conclusions which a study of these and similar sections seem to justify may be briefly stated: (1) That residuary clays (and, by inference, other clays of equal compactness) were passed over by a thick ice-sheet (*a*) in some instances without removal or even serious disturbance, while (*b*) in other cases they were removed, or contorted and broken up, just as the lower till and associated deposits have been found to be on both sides of the Atlantic;[*] and (2) that the plane of contact between glacial drift and subjacent beds of residuary clay (and, by inference, other clays of similar consistency) is not necessarily clearly defined—the materials so intermingling as to form a thin intermediate stratum of composite character. Analogy with the many recorded instances in which the upper surface of the lower till is scored and smoothed[†] and with the "striated pavements" of Hugh Miller, would, however, seem to justify the assumption that residuary clays may sometimes be smoothed and furrowed.

Farley, Iowa, July 30, 1879.

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[*] See Lyell, "Student's Elements," 1871, p. 179, and Antiq. Man, 1873, p. 262; Croll, "Climate and Time," Am. Ed., p. 465; Geikie, "Great Ice Age," Am. Ed., pp. 144–5; Chamberlin, Geol. Wis., 1877, vol. ii, p. 219; Foster and Whitney, Geol. Lake Superior Dist., 1851, pt. ii, p. 245; Logan, Geol. Can., 1863, pp. 898, 902, 906; Reid, Geol. Mag., vol. vi., p. 379; LeConte, this Journal, vol. xviii, p. 40; Hinde, Canadian Journal, April, 1877; McGee, Proc. Am. Assoc., 1878.

[†] Chamberlin, loc. cit., p. 226; Lyell, "Student's Elements," p. 178; Geikie, loc. cit., p. 151, and also Trans. Geol. Soc. Glasgow, 1863, vol. i, pt. ii, p. 68, and "Glacial Drift of Scotland," p. 67; Read, Geol. Ohio, 1878, vol. iii, pt. i, p. 312; Hinde, loc. cit. (striated pavements also occur near Toronto and are here described); Dawson, cited by Logan, loc. cit., p. 919; Reid, loc. cit.; Chambers', Edin. New Phil. Jour., vol. liv, p. 272; and Smith, "Newer Pliocene Geology," p. 129. The last two authorities are cited by Croll, loc. cit., p. 256.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *On the Theory of Fractional Distillation.*—THORPE has given a striking instance of the general law announced by Wanklyn and confirmed by Carey Lea and Berthelot, that when two liquids of different boiling points are mixed together in equal quantities by weight, and subjected to distillation, the quantity of each constituent in the distillate is proportional to the product of its vapor-density and vapor-tension at the temperature of ebullition of the mixture; and hence that when the vapor-tensions of the two liquids are inversely proportional to their vapor-densities, the liquid will distill unchanged. Berthelot, for example, observed that a mixture of 90·9 parts carbon disulphide, boiling at 46·6°, vapor-density 38, and 9·1 parts ethyl alcohol boiling at 78·4, vapor-density 23, behaved on distillation like a homogeneous liquid; the ratios obtained by multiplying the vapor-tensions and densities being 88·5 and 11·5. Thorpe's results were obtained with a mixture of equal volumes carbon tetrachloride, boiling point 76·6°, vapor-density 76·7, and methyl alcohol, boiling point 65·2°, vapor-density 15·97; and he noticed that 46·5 per cent of the whole boiled constantly between 55·6° and 55·9°, or nearly 10° lower than the boiling point of the most volatile constituent. By vapor density determinations, the composition of the mixture by weight was found to be 78·1 CCl_4 and 21·9 CH_4O; a ratio almost identical with that obtained by multiplying the vapor-tensions of the two liquids at the temperature of the boiling point of the fractions (55·7°) by their respective vapor densities. Hence a mixture of 1 part methyl alcohol and 3·6 parts carbon tetrachloride, boils like a homogeneous liquid at about 10° lower than the boiling point of the methyl alcohol, the more volatile of the two liquids. On continuing the distillation of the liquid remaining in the flask, the several fractions gave numbers showing clearly that the CCl_4, although having the higher boiling point, passed over in largest quantity in the first fractions, the quantity of pure methyl alcohol increasing as the temperature rises. Thorpe suggests, as a lecture-experiment to show the effect of such a mixture, that into one of three barometer tubes over mercury, a few drops of methyl alcohol be put, an equal quantity of carbon tetrachloride being placed in the second, and a mixture of the two in the proportion of 3 c.c. of CH_4O and 5 c.c. of CCl_4 in the third. In the first tube the mercury will be depressed about 80 mm. and in the second 70 mm.; while in the third the depression will be 130 mm.—*J. Chem. Soc.*, xxxv, 544, Aug. 1879. G. F. B.

2. *On the Solidifying point of Bromine.*—Because of the widely differing values given for the point at which bromine solidifies, PHILIPP, at the suggestion of Rammelsberg, has undertaken to redetermine it. In order to purify the bromine, it was

dissolved in caustic baryta water, the washed barium bromate converted into bromide by ignition, and this distilled with sulphuric acid and potassium dichromate. The distillate was washed and dried; a part by agitation with concentrated sulphuric acid and distillation and a part by distillation from calcium chloride. Thus purified, the bromine solidified between −7·2° and −7·3°, phenomena of surfusion not being noticed. This result corresponds with that obtained by Regnault −7·32°. The non-purified bromine solidified at −9° to −10°. To test the influence of foreign admixture, the author made direct experiments and found that while 2 per cent of iodine did not materially raise the solidifying point, 3 or 4 per cent of chlorine lowered it even to −15°. Solid bromine has a brown color and a conchoidal fracture; though after exposure to the air, it takes a gray color recalling that of iodine, and appears crystalline.—*Ber. Berl. Chem. Ges.*, xii, 1424, July, 1879. G. F. B.

3. *On the Thermic formation of Hydrogen silicide and of Ethyl silicate.*—Ogier has studied, in Berthelot's laboratory, the heat-relations attending the formation of hydrogen silicide and of ethyl silicate. The hydrogen silicide was prepared by the action of sodium on tribasic siliciformic ether, and was free from hydrogen. It was burned with oxygen in the small glass chamber of a water calorimeter, being ignited by a small induction spark. The quantity of gas used was determined from the increased weight of the chamber and of a tared eduction tube filled with fragments of pumice moistened with sulphuric acid. In this way the heat of combustion of one equivalent of SiH_4 was found to be 324·3 calories. From this, since Si (cryst.) $+O_4 = +211·1$ cal. and $4(H+O) = +138$ cal., $SiH_4 + O_8 = +324·3$ cal. as above, we have $Si + H_4 = +24·8$ calories. Hence in uniting Si and H_4 evolve 24·8 calories, a number very near that which the formation of marsh gas gives, +22.

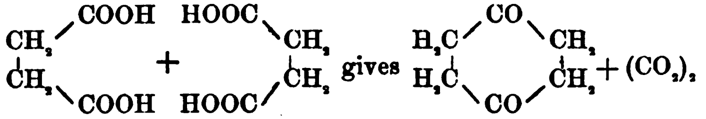
The heat of formation of silicic ether was determined in two ways: first, analytically, by decomposing it by means of a large quantity of water, into silicic acid and alcohol, at the ordinary temperature; and second, synthetically, by forming it directly by the action of silicium chloride upon absolute alcohol. The former method gave +21·6 calories as the heat evolved in the decomposition. Taken with the contrary sign, it expresses the heat absorbed in the formation of the ether from the alcohol and silicic acid. Subtracting from this the heat corresponding to the solution of the alcohol in water, there is left −11·44 calories, the true heat of formation of silicic ether. The latter method showed that the heat evolved when one equivalent silicon tetrachloride acted on 26 equivalents of alcohol was 42·3 calories at 10°. Making the necessary corrections, the heat of formation of silicic ether obtained in this way, is −11·56 calories, a close accordance with the number obtained analytically, −11·44. Referred to a single equivalent of alcohol instead of four, it becomes −2·9.—*Bull. Soc. Chim.*, II, xxxii, 116, 118, Aug., 1879. G. F. B.

4. *On Organic Ultramarines.*—DeForcrand has succeeded in producing an ultramarine containing ethyl. Though Unger first succeeded in replacing half of the sodium in ultramarine by silver, Heumann first produced an ultramarine in which this replacement was complete. This yellow silver-ultramarine served as the starting point in the new researches. When heated, dry, with a metallic or an organic chloride, silver chloride and a new ultramarine result. Silver ultramarine was prepared by heating in sealed tubes for 15 to 16 hours, four or five grams of blue ultramarine and 8 or 10 grams silver nitrate in concentrated solution. A beautiful yellow powder in transparent grains is thus obtained, which contains 46 to 47 per cent of silver, and has all the properties of an ultramarine. From it the blue ultramarine may be regenerated either by heating with a strong solution of sodium chloride for twenty-five hours, the reaction being then limited by the inverse one; or by heating the two without water to a high temperature, in which case the conversion is complete. If other metallic chlorides be used in place of sodium chloride, a series of ultramarines is obtained containing the metal used in place of the silver, there being a definite temperature for each at which its formation is a maximum. The potassium and rubidium ultramarines are greenish blue, that of lithium is blue, of barium yellowish-brown, of zinc violet, of magnesium gray, etc. Mercuric chloride gives a gray mercury-ultramarine when heated directly with the blue sodium ultramarine. Heated with ethyl iodide in a sealed tube to 180° for from fifty to sixty hours, and repeating the operation several times, silver ultramarine is decomposed, yielding a clear gray powder with a reddish cast, which even at 100° evolves ethyl sulphide. If, however, this powder be intimately mixed with sodium chloride before heating it, only a trifling evolution of ethyl sulphide takes place, and the mixture becomes blue owing to the regeneration of sodium ultramarine. The reaction is complete at the temperature at which the sodium chloride melts, the ethyl being evolved as chloride. That the gray powder actually contained ethyl was proved by heating a gram of it to redness in a tube through which an inert gas passed, the products being collected in a solution of mercuric chloride. A white crystalline precipitate of $(C_2H_5)_2S.HgCl_2$ was formed, thus proving the gray powder to be a true ethyl ultramarine. Similar compounds were obtained with allyl, amyl and benzyl, and with the compound ammoniums.—*Ann. Chim. Phys.*, V, xvii, 559, Aug., 1879.

G. F. B.

5. *On the Synthesis of the Benzene Ring.*—Perhaps no hypothesis in science has been more fruitful of results than the classic one of Kekulé in relation to benzene, which supposes that its six carbon atoms form a closed ring. Since the few synthetic methods, by which this ring has until now been formed, do not decide between this and the so-called prismatic arrangement of the benzene nucleus, Von Richter has sought for and discovered a direct synthesis of the benzene ring which strongly confirms the hypoth-

esis of Kekulé. Exactly as monobasic acids yield common ketones, so the diabasic acids should give double ketones having the carbon atoms in a ring form. Thus from succinic acid, di-ethylene-di-ketone is formed:



$+(H_2O)_2$. The potassium, sodium, magnesium, calcium and lead salts of succinic acid were submitted to distillation under various conditions. A dark colored oil in greater or less quantity was always obtained, having a ketone-like odor, but from which no fractions of exact boiling point were obtainable. By distilling the fraction boiling between 160° and 250° with zinc dust, considerable benzene was obtained. Moreover hydroquinone was contained in the wash waters of the crude oily distillate. Since the above di-ketone yields both these bodies readily, $C_6H_8O_2 = C_6H_6O_2 + H_2$ and $C_6H_6O_2 + Zn_2 = C_6H_6 + (ZnO)_2 + H_2$, it may be considered as proved that the benzene nucleus has the constitution assigned to it by Kekulé. Moreover this experiment fixes hydroquinone as a para-compound and establishes the quinones as double ketones.—*J. pr. Ch.*, II, xx, 205, Aug., 1879. G. F. B.

6. *On the Sulpho-ethers of the Polyatomic Alcohols and the Carbohydrates.*—CLAESSON showed, a short time ago, that chlorsulphuric acid, $SO_2\left\{\begin{matrix}OH\\Cl\end{matrix}\right.$, acted on the monatomic alcohols to form mono- or di-sulphuric ethers. He has now extended the reaction to the polyatomic alcohols and has obtained from glycol, ethylene disulphate, from glycerin, glyceryl trisulphate, from erythrite and mannite, tetra- and hexa-sulphates respectively, and from dulcite, a penta-sulphate. The carbohydrates of the glucose group give by this treatment, isomeric compounds probably monochlor-tetrasulphates. At least this is the case with dextrose whose derivative is crystallizable and has the composition $CH_2OSO_2OH.(CHOSO_2OH)_3.CHCl.CHO$. Cane sugar, starch, etc., are first inverted and then the above compounds are formed. These polysulphates of the optically active alcohols and carbohydrates have an increased rotatory power to the right. Milk sugar gives dextrose and galactose.—*J. pr. Ch.*, II, xx, 1, Aug., 1879.

G. F. B.

7. *On the Conversion of Aurin into Trimethyl-pararosaniline.*—DALE and SCHORLEMMER, by acting on aurin with ammonia, have sought to obtain the intermediate products between this substance and para-rosaniline. As ammonia gave so much trouble, they tried methylamine and found that in aqueous solution, this base acts readily on aurin at 125° and transforms it almost entirely into a purple body, possessing all the properties of a trimethyl-rosaniline: $C_{19}H_{14}O_3 + (CH_3NH_2)_3 = C_{19}H_{14}(CH_3)_3N_3 + (H_2O)_3$. Trimethylamine acts similarly, converting the aurin into purple coloring matters.—*J. Chem. Soc.*, xxxv, 562, Aug., 1879.

G. F. B.

8. *An Induction Balance.*—Professor J. E. Hughes has lately devised an instrument which promises to be of great use in determining the amount of the constituents of alloys. It is based upon the principle that the induced current in a secondary coil depends upon the character and amount of metal which forms the core of the primary. A portion of the apparatus Professor Hughes calls a sonometer; this consists merely of two primary coils which are placed with opposing poles about a meter apart on a divided scale. Between them slips a secondary coil which is connected with a telephone. If the primary coils are exactly equal, and are traversed by the same electric current, one will hear no sound when the secondary coil is exactly between the primary coils. This point of balance is called the zero of the sonometer. The circuit running through the primary coils is provided with a microphone, and a clock ticking upon the support of the microphone supplies the necessary change of resistance in the electric circuit. If the equality of the sides of the sonometer is disturbed by the introduction of metals on one side or the other, the telephone announces the inequality and the secondary coil has to be moved nearer one primary coil than another. The number of degrees moved is a relative measure of the difference of the metals. The extreme sensitiveness of this balance is shown by numerous experiments. It is also of use as a coin detector—any difference in the quantity or quality of the metal being instantly shown. W. Chandler Roberts, Chemist of the Mint, has tested Professor Hughes' balance, and gives a number of curves produced by different alloys, and shows that the balance can detect smaller quantities of metals in the composition of alloys than the methods hitherto used. He suggests also "that the balance may afford a simple means of detecting variations in the molecular structure of alloys and for detecting allotropy in metals with greater accuracy than has hitherto been possible."—*Phil. Mag.*, July, 1879, p. 50.
J. T.

II. GEOLOGY AND NATURAL HISTORY.

1. *Notice of Volcanic Phenomena and Earthquakes during* 1878.—The statistical review of these phenomena recently published by Professor C. W. C. Fuchs shows the unusually large number of *twelve* eruptions during the year; most of which occurred in remote localities and from little known volcanoes. In Vesuvius there was but slight activity, with a small flow of lava in September and November. On January 10, smoke was seen from two hitherto unknown volcanoes at the southern point of South America. On the same day a great eruption occurred in the island of Tanna, one of the New Hebrides, followed by a second outbreak on February 4. Simultaneously yet another eruption occurred in the island of Birara in the group of New Britain. Another eruption took place in February from the volcano Isluga in South America (lat. 19° 10′ S.), where several villages were destroyed by the lava streams and accompanying

earthquake. Other eruptions were from Mount Hecla (March), from the Asamayama in Japan, from Cotopaxi (October), from the Tepaco, the Sitna, and the Isalco in San Salvador, from the volcanoes of the Aleutian Islands and in the Society Islands. Dr. Fuchs also records the great mud eruption near Paterno in Sicily, which began on Dec. 10, and still continued at the end of the year.

The number of earthquakes reported during 1878 amounts to 103. But among these are many complete earthquake periods during which the shocks continued with short intervals for hours, days or even weeks in the same locality. If every shock were counted the total would be many times greater.

The earthquakes were most frequent in winter and autumn—thirty-nine occurring in winter, twenty-six in autumn, and nineteen each in summer and spring. The most violent and destructive earthquakes occurred on January 23 in Peru and Boilvia, and on October 2 in San Salvador. (Also on April 12 in Venezuela. This Journal, Feb., 1879, pp. 158, 159, 161.) Of European earthquakes the following deserve notice. On January 28, about noon an earthquake occurred in the northwestern part of France and the south of England, particularly distinct in Normandy. Repeated shocks were felt in northwestern Switzerland and the southwest corner of the Black Forest on January 16, 17 and March 29. Other instances of repeated earthquakes are Innsbruck (Jan. 3, 10, 11, Feb. 2, Aug. 9), Gross Geran (Jan. 2, March 25), Lisbon (Jan. 26, 27, June 8), Constantinople and vicinity (April 19 to end of May). Less remarkable for its violence than for its extent was the Low-Rhenish earthquake of Aug. 26. The observations in this case were unusually exact and numerous, which gives additional interest. It began about 9 A. M., and was best observed in Cologne. Here it consisted of an undulatory rising and sinking of the ground, which increased in intensity to an alarming extent. On the cathedral tower the smaller bell struck several times, and in many places the houses showed cracks. At the end of the oscillations a dull subterranean noise was heard, and a second shock was observed by many persons. At other places the phenomena were similar. The area affected by the first shock may have measured over 2000 geographical square miles, as its outlines may be indicated as follows: Arnsberg and Hanover on the north, Offenbach on the Main and Michelstadt in the Odenwald on the southeast, Strasburg, Paris and Charelville in the south, Liége and Brussels in the west, and Utrecht in the northwest.

From collating the most reliable observations of time Professor Klinkerfues infers that the velocity of the earthquake in the ground was 6·78 geographical miles per second, and that its origin was between 6·3 and 8·7 miles below the surface.

It is remarkable that the phenomenon was only noticed at the surface and was more intense the higher the observer was above the ground, while miners working at a depth of 300 meters did not feel it at all.

A similar fact has been noticed in regard to some recent earthquakes in our Rocky Mountain region, which, though quite severe on the surface were not felt in the mines below.—*Condensed from Nature*, Aug. 14, 1879. C. G. R.

2. *The Geology of the Diamantiferous Region of the Province of Paraná, Brazil;* by ORVILLE A. DERBY, M.S. (Proc. American Phil. Soc., May 16, 1879.)—This paper records the results of a recent trip by Mr. Derby, to the Province of Paraná, in continuation of the labors of the late Geological Commission in the same region; and it also gives us for the first time an accurate idea of the relations of the deposits of extreme southern Brazil to those of the other parts of the Empire. The Province of Paraná, one of the more southern ones of Brazil, lies between the provinces of Sâo Paulo and Santa Catharina, and reaches from the Atlantic to the Rio Paraná. In its topographical and geological features it resembles, to a certain extent, the two provinces which border it on the north and south. The coast range of mountains, or Serra do Mar, traverses it in a north-south direction, leaving along the coast a low belt, from ten to twenty miles broad. The remainder of the province is, strictly speaking, a plateau, from 800 to 1000 meters high; but Mr. Derby divided the entire province into two distinct topographical regions, a mountainous region, bordering the coast and extending inland about 100 miles, and a plateau region, occupying the central and western parts of the province. The first region is entirely composed of metamorphic rocks, highly inclined and with a general strike east-northeast. These, in the coast belt, and in the Serra do Mar proper, are mostly granites and gneisses, representing the Archean of Rio de Janeiro and northern Brazil; but further west they consist principally of metamorphic schists, quartzites, marbles, etc., and represent the Lower Silurian or Cambrian of Bahia, Minas Geraes and northern Brazil. A second geological province extends from the metamorphic westward, a hundred miles or more, forming the far-famed "Campos Geraes," and made up of shales and coarse and fine sandstones. In the shales of this group at Ponta Grossa, were discovered species of *Lingula*, *Discina*, *Spirifera*, *Rhynchonella*, *Streptorhynchus* and *Vitulina*, strongly resembling, and probably identical with, those of the Devonian of the Amazonas. Other fossils were also obtained. The entire western part of the province is apparently formed of a heavy bed or series of beds of trap, overlying a considerable thickness of soft red sandstone, which, in turn, overlies the shales and sandstones of the second region. The rocks of the third region resemble in a striking manner the Triassic rocks of North America.

The diamonds are found principally in the valley of the river Tibagy, and more rarely in other river valleys, as they cross the second or Devonian area, above defined. The observations made tend to prove that the sand and gravel containing the diamonds were derived from the underlying Devonian sandstones, which had previously obtained their material from the lower-lying metamorphic series. The gems are found in the sands of the river, and in more elevated gravel banks, called "dry washings." R. K.

3. *Serpentine Marble.*—A beautiful variety of mottled serpentine marble is worked at a point on Broad Creek in Harford county, on lands of the Havre Iron Co., Maryland. Dr. Genth states that there are three beds of serpentine, associated with chloritic and other magnesian rocks in the mica schist formation of the region. The chief bed is about 500 feet thick, and is traceable by its outcrop for about 1500 feet.

4. *The Gymnospermy of Coniferæ;* by Dr. L. CELAKOVSKY. A paper in *Flora* for June, 1879, Nos. 17 and 18.—Celakovsky, who takes a high position as a morphological botanist, mentions that in the year 1874 he published in *Flora* an article opposing gymnospermy. He now announces that he has changed his opinion, having satisfied himself of the truth of this doctrine. The agent of conversion was a monstrosity of the Norway Spruce cone, like that from which Stengel made out the now accepted morphology of the cone, and the same monstrosity as that which Braun studied in the Larch, deducing from it the accepted doctrine many years ago. The essential point in this monstrosity is that the bracts of the abnormal catkin develop into leaves, and the carpellary scale before it into a pair of leaves transverse to the bract. The abietinous carpel consists of these two leaves united by their posterior edges (i. e., those next the axis of the cone) into a scale, the back of which therefore faces the axis of the cone, and bears the ovules. The lower part of these catkins is usually normal, the apex by prolification is gradually transformed in the manner here specified, and becomes a leafy branch. Dr. Engelmann, in this Journal, three years ago, gave a confirmatory account of an analogous monstrosity in the Hemlock Spruce, but in which the transformation was at the base of the cone, the lower bracts leaf-like and with a pair of leaves in their axil, the following bracts more and more scale-like, the geminate leaves in their axil were partially united, next forming a scale with a cleft or notched apex, then an entire carpellary scale, in the axil of a normal bract.

Celakovsky, having now seen the Spruce monstrosity for himself, adopts the inevitable conclusion, and applies it well to the settling of the question of gymnospermy. He declares that the dorsal origin of the ovules of the Abietineæ proves that it is no axillary production, and thus the main support of those who take the ovule for a simplified female flower falls to the ground. Moreover, the ovules of Coniferæ in retrograde metamorphosis never change into shoots, but simply disappear. If flowers, they would be expected sometimes to become foliaceous branchlets. So Celakovsky regards it as demonstrated that they are outgrowths from the dorsal face of the leaf, analogous to the sori and indusia of Ferns. He cites the indusium of *Hymenophyllum* as an instructive analogue, only it is marginal; that of *Davalia* is somewhat dorsal; that of *Cyathea* wholly so and yet cup-shaped. He goes on to say that the gymnospermy of *Abietineæ* being thus proved, that of the rest of *Coniferæ* follows of course; that Braun has seen similar prolification in the catkins of *Taxodineæ*, in which the carpel-scale was replaced by a bud; that, although the carpel-scale in *Abietineæ* consists of two leaves, the bud may in other cases develope more than two leaves, so that the lobed scale of *Cryptomeria* may be composed of as many leaves as there are lobes. Moreover, although the ovules in *Abietineæ* originate from the scale, the greater part of the scale is developed after the formation of the ovules; and in *Cupressus* the scale is developed even as late as the following spring, while the ovules are produced in the autumn. However the case may be disguised, Celakovsky asserts his firm conviction, 1st, that an ovule can only be developed as depending on a carpel, and, 2d, that its nucleus represents the macrosporangium of vascular Cryptogams. He adds that this is the logical consequence of the theory of descent, and must be true if the doctrine of the genetic connection of the vegetable world is true. He considers that Van Tieghem and Strassburger have proved the seemingly simple scale of *Cupressineæ* and *Taxodineæ* to be composed of bract and carpel-scale united [which indeed is evident in *Taxodineæ*], and that Braun has confirmed this by the study of proliferous cones. As to the development of ovules earlier than the carpels they belong to, this is said to have been observed in some Angiosperms also, as in *Cuscuta*, in which at first four naked ovules appear. The anatomical organogenist may argue from this that ovules and carpels are independent productions, but Celakovsky insists that he will argue wrongly.

This brings our author to the consideration of the structure of *Taxineæ*. This is environed with difficulties, and explanation is only conjectural. Here the disc, arillus, cupula, or whatever it be called, makes its appearance where no trace of carpellary scale is to be seen. Celakovsky inclines to the view that this organ, occurring in whatever form, is most probably the carpellary scale itself, very tardily developed. In *Dacrydium* the cupule is homologous with that of *Taxus*, but oblique. *Cephalotaxus* has no scale and no cupule, but seems to correspond with *Cupressineæ*, and shows at maturity a small flattened rudiment between the two ovules, which is probably a rudimental carpel-scale. *Ginkgo* is the most puzzling; yet it seems probable that the biovuliferous peduncle represents the abietineous carpel-scale, the peduncle itself being its elongated base. The cupule of Taxus may be either a simple circular carpel, or may consist of more than one carpel. The apparently terminal ovule of *Taxus* and *Torreya* he would regard as axillary to one of the uppermost subtending bract-scales; for he will not concede that the ovule can be wholly destitute of a carpellary organ. Yet he might do so, in one sense; for if the carpel may develope very late and very imperfectly or very little, it may sometimes not visibly appear at all, and so the phyllome be reduced to the ovular outgrowth.

Finally, Celakovsky notes, that if the ovule of *Taxus* and *Torreya* be axillary to an uppermost scale, it would originate not from the dorsal but from the ventral face, i. e. from the upper side of the leaf; which would distinguish *Taxineæ* from all true *Coniferæ*,—a view which would not be destitute of important support. For both Braun and Mohl have seen apparently androgynous scales in some *Abietineæ*. In a monstrous Larch-ament, among carpellary scales with normally dorsal ovules, Braun found one with ovules on the opposite face; and Mohl describes and figures an androgynous inflorescence of White Spruce, with pollen-sacs on the outer face, and on the other a pair of knobs which from their form and position might be taken for imperfectly developed ovules. But this latter case seems most ambiguous. If it was in a male catkin, the upper part of which had become female by the development of carpel-scales in the axil of stamens partially transformed into bracts (which is the case we have before us in a monstrosity of Hemlock Spruce), then the quasi-androgynous scale in question may have been the normal abietineous carpel-scale itself, with the polleniferous bract behind it and connate with it.

The androgynous spike of Hemlock Spruce before us is below normally staminate; above some anthers are slightly scarious-winged at one side of the projecting tip, another has this wing developed into a bract-like body on the whole of one side; next there is a bract with a single small pollen-sac on one side of its back and in its axil a well-formed and biovulate carpel-scale.

G. E. & A. G.

5. *Contributions to American Botany*, IX; by SERENO WATSON. From *Proceedings of American Academy of Arts and Sciences*, vol. xiv, July, 1879, p. 213 to 303, and an index.—Mr. Watson, in preparing the Monocotyledoneæ for the Botany of California, came upon the order *Liliaceæ*, which is well represented in Pacific North America; and he had to consider how the genera and higher groups should be disposed. This led to a wide study of the order and a strict scrutiny of the American species; and the present "*Revision of the North American Liliaceæ*," occupying the greater part of the "Contribution" before us, is the result. It is generally agreed that this order is to have the wide extension which was given to it by the present writer a dozen and more years ago; and the proper collocation of its diversified forms, with interlaced affinities, has been a problem of no small difficulty. Mr. Baker, in England, has attempted the task for the order generally, and has sedulously elaborated some of the North American, but more of the Old World and the South American, genera and tribes. His arrangement and his systematic views are in many respects satisfactory, in some unsatisfactory as respects North American botany. Mr. Watson has the latter primarily in view, but still has to adjust the American genera into the general system. The arrangement he has planned consists of three *series*, the first of which parts into two *subseries*, and includes sixteen tribes, some of them divided into subtribes. The great endeavor has evidently been to make natural groups—and this endeavor has been really successful. The next thing is to assign characters, and here comes the difficulty. Absolute

characters of the leading groups are not to be had, even when North American forms only are considered. Those who imagine they could do better than Mr. Watson has done should make trial before they criticise. The character of the pericarp, whether baccate or capsular, the nature of the stock, whether bulbous, tuberous or rhizomatous, the nature of the seed-coat, the inflorescence, direction of anthers, union or separation of styles, are all good characters to a certain extent, and all fail to furnish unexceptionable marks to distinguish the higher groups when natural associations are sought. It is not easy to ascertain what diagnostic characters in this monograph are most to be trusted. But the nature of the bracts (on the one hand scarious, on the other foliaceous or none) takes the lead in the first two series, and is followed by the persistence or deciduousness of the perianth, the insertion of the stamens whether on the perianth or at its base, the dehiscence of capsule,—all matters of little physiological importance, but for that reason perhaps surer guides to affinity than the more prominent adaptive characters. However, it may be said that the first series answers to the *Asphodeleæ*, with *Yucca* and *Hemerocallideæ* added; the second to the true *Liliaceæ* with *Uvularieæ* and *Trillieæ* added; the third to *Melanthaceæ*, with the tribe *Tofieldieæ* appended. Thus disposed, it is doubtless judicious to designate the three primary groups as "series," and not as suborders, and to throw the stress upon the tribes.

The Melanthaceous series, which in our view best divides into the *Colchiceæ*, *Veratreæ* and *Tofieldieæ*—the first not American—is here divided into the *Veratreæ*, *Helonieæ* and *Xerophylleæ* (which two we should combine), into the midst of which the *Tofieldieæ* are intercalated. This last tribe, which should end the series, is quite exceptional, and is well composed of *Tofieldia*, *Pleea* and *Narthecium*. Its marks are the equitant leaves, introrse anthers with parallel cells, and caudate seeds; but to bring *Narthecium* under the remaining character of "styles distinct or none," it is defined as destitute of style, but with "the slightly lobed stigma sessile upon the attenuated apex of the ovary." This is really much nearer the fact than would be supposed, as the cells of the ovary actually do taper up into the subulate style (as it has always and most naturally been termed), so that in the mature capsule the upper tails of the seeds reach up to within a short distance of the small stigma.

In a linear order it has not been practicable to approximate the *Convallarieæ* of the first series with the *Uvularieæ* of the second. The division of *Uvularia* gives a gratifying opportunity of dedicating a New England genus to the memory of one of the best of New England botanists, the late Wm. Oakes (*Oakesia sessilifolia*, with its relative of the southern mountains, *O. puberula*); but he would not have relished the dismemberment of the Linnæan genus upon the characters, good as they are, neither in fact do we. The formation of the tribe *Yucceæ*, of *Yucca* and *Hesperaloe*, strikes us as excellent; and it seems right not to adopt the supposed second species of *Hesperaloe* until it is better known. Its principal distinctions (longer anthers and shorter style) may indicate heterogone dimorphism, which would be a novelty in the order.

Tribe *Nolineæ*, of the first series, must be regarded as an excellent group, composed of *Dasylirion* and *Nolina;* and it is gratifying to find that the outlying genus, *Nolina*, founded long ago, on a single Georgian species, is the northern representative of a considerable Texano-Mexican group, named *Beaucarnea.* It were to be wished that the plan of this Revision had allowed more citation of generic synonymy, and that it had been more explicitly stated that *Beaucarnea* is only *Nolina.* This union, indeed, is one of the happy hits of the present monograph.

As has been suspected, the Californian *Schœnolirion album* of Durand proves to be quite distinct from the Atlantic species on which that genus was founded. So Mr. Watson has embraced the opportunity, here offered, to dedicate a peculiar Californian genus to Judge Hastings—a judicious patron both of botanical and legal learning. Except for his exertions, his own liberality and his direction of the liberality of others, we could not have had the Botany of California, which Mr. Watson may now soon bring to a completion. The reader finds no mention of this under the genus *Hastingsia*, p. 217, nor under the species, *H. alba*, p. 242. But an appropriate reference is made on p. 286.

Leucocrinum, Nutt., was conjectured by Endlicher to be the Mexican *Weldenia*, but it has just now been ascertained at Kew that *Weldenia* is a Commelynaceous genus.

Our species of *Allium* as now worked out by Mr. Watson with great painstaking, are thirty-six in number, exclusive of the introduced *A. vineale.* Some characters might be made more of in living plants, such especially as those furnished by the so-called "crests of the ovary." In *A. stellatum* these crests are remarkably developed, radiating from around the base of the style and recurving, the notch at the end of each fitting over the base of the alternate filaments, and the under side is nectariferous and attractive to bees. The flowers are proterandrous.

In separating the two species of *Maianthemum* we should have unhesitatingly referred the large Pacific coast form to *M. bifolium.* We should not have distinguished *Lilium Grayi* as more than a form of *L. Canadense*, one which extends northward to the central parts of New York. In view of geographical range, size, and general appearance, we should never have thought of *Uvularia flava* as a synonym of *U. grandiflora.* Mr. Watson finds good characters in the shape and markings of the capsule to separate *U. grandiflora* from *U. perfoliata.* Has any one ripe fruit of the small, yellow-flowered, *U. flava?*

Chamælirium Carolinanum, Willd. This specific name is properly restored. It was the original name under this genus; and the name *luteum* is a false one (though the plant was *Veratrum luteum* of Linnæus), the blossoms being white without a tinge of yellow, duller white in the female plant, pure white in the male, the pedicels equally of this color.

No space is left in which to notice the Notes upon the Affinities and geographical Distribution of *Liliaceæ*, nor the Descriptions of Some new Species of North American Plants, about fifty in number, which make up the second part of this important "Contribution." Among them is a new *Bolandra* and a new *Sullivantia* from Oregon, both very much like (we fear too like) the original species. Here and in the Bibliographical Index, the name *Sullivantia Ohionis* is changed (perhaps accidentally) to *S. Ohioensis*. We know of no law against genetive names of geographical more than of other places or stations, and such are not extremely uncommon. The name *Ohionis* was purposely chosen, and we hope may be retained.

The interesting new Erigoneous genus *Hollisteria*, discovered by the enthusiastic Mr. Lemmon (in San Luis Obispo Co., east of the Coast Range) is of rather doubtful interpretation as to some points of structure. The inflorescence we suppose to be only seemingly axillary, the involucre is possibly a genuine trimerous one, and we take the two small stipule-like leaves to be real stipules,—a point which the published character does not decide, though it is implied in describing the leaves as alternate.

Being one of the most important of recent contributions to North American Botany, this publication deserves even a fuller notice than we can here give it. A. G.

6. *Musci Fendleriani Venezuelenses.*—Among the collections made by Mr. Augustus Fendler in Venezuela, in 1854–5, was a very fine one of the Mosses of the region which he explored. It was purchased by the late Mr. Sullivant and in part studied by him, and drawings of a large number of the species were made by Mr. A. Schrader under his direction. With the exception of a single set, accompanying the drawings, which was bequeathed to the Herbarium of Harvard University, the whole collection was made over to Mr. Schrader, the draughtsman, to be distributed by sale among the bryologists. But, as a very large proportion of the species were new, it was desirable that they should all be authentically named, and the new ones described before the sets were offered. This has now been satisfactorily and most obligingly done by Dr. Karl Müller of Halle, the accomplished author of the Species Muscorum, and publication made in the Linnæa (xlii, parts 5 and 6), this giving the highest value to the collection. Mr. A. Schrader, of Columbus, Ohio (234 West State street), now offers these sets to botanists, at $12 for the 145 species, in good specimens, with a printed form of ticket bearing the numbers, and a copy of Dr. Müller's memoir (in Latin) in the Linnæa, enumerating and describing them. There are thirty-nine sets, all of equal completeness and value. To secure them early application should be made to Mr. Schrader. A. G.

7. *Dictionnaire de Botanique ;* par M. H. Baillon.—The first part of the second volume has appeared, containing articles from *Chlænacées* to *Cistus*. No small part of the eighty pages are occupied by two articles, *Chlorophylle* and *Circulation*, each as it were a treatise. A. G.

8. *Miscellanea.*—The following are the more important botanical publications which have accumulated upon our table:

Transactions of the Linnean Society of London. Second Series, parts 5 and 6, of vol. i.—These contain Casimir DeCandolle's paper on the geographical distribution of the *Meliaceæ*, with a map; New British *Lichenes* by Leighton, with a fine plate; *Liliaceæ* and other petaloideous Monocotyledons of Welwitch's Angolan Herbarium, by Baker; New Zealand *Lichenes*, by Knight; the fine paper on the morphology of *Primulaceæ*, by Masters; a new genus of parasitic *Algæ* and conidial fructification in the *Mucorini*, by D. D. Cunningham; Fungi from Queensland, by Berkeley and Browne, and the Rev. George Henslow's memoir on self-fertilization in plants, which has been reviewed in this Journal at some length.

Nouvelles Archives du Museum.—The first volume of the second series begins with Decaisne's full and interesting monograph of *Ligustrum* and *Syringa*, with three plates. There are thirty-seven species of *Ligustrum*, and eleven of *Syringa*, including *S. Amurensis* and two allied species with rotate corollas, the genus *Ligustrina* of Rupprecht.

Rivista Botanica dell' Anno 1878, di FEDERICO DELPINO, 1879, Extr. Ann. Scientifico Italiano, Ann. xv.—A general review of botanical publications of 1878. Signor Delpino, now Professor of Botany in the University of Genoa, sends us also continuations of his valuable papers on dichogamy of flowers, and some other interesting essays, which we hope to review later. A. G.

III. ASTRONOMY.

1. *Ephemeris of the Satellites of Mars for Oct. and Nov.*, 1879.—The following ephemeris, computed from Prof. Hall's elements of the satellites of Mars, gives the approximate position angles and distances of the satellites about the time of elongation. Only the times of those elongations are given which may be observed in America. On Nov. 1 the probable error of the computed angle of position is for Deimos ± 0°.6 and for Phobos ± 8°.1.

Deimos.

Date.	Wash. M. T.		Pos. Ang.	Dist.	Date.	Wash. M. T.		Pos. Ang.	Dist.
	h	m	°	″		h	m	°	″
Oct. 10	10	46	232·		Oct. 30	15	34	232·	
12	8	13	52·1	60 80	Nov. 1	12	0	52·7	66·88
13	14	31	52·		3	9	27	232·	
15	12	58	232·		4	15	45	232·	
17	9	25	52·	62·2	5	6	54	52·	
18	15	43	52·		6	13	12	52·	
20	13	10	231·		8	10	38	231·	66·6
22	10	37	51·3	63·73	9	16	56	231·	
23	16	55	51·		10	8	5	51·	
25	14	22	231·		11	14	23	51·	
27	11	49	51·		13	11	50	231·	
29	9	16	232·	65·	15	9	17	50·8	64·88

Phobos.

Date.	Wash. M. T.		Pos. Ang.	Dist.	Date.	Wash. M. T.		Pos. Ang.	Dist.
	h	m	°	″		h	m	°	″
Oct. 10	8	2	55·	24·5	Oct. 28	8	30	234·	
	11	53	235·			12	19	54·	
	15	41	55·			16	9	234·	
11	7	0	55·		29	7	28	234·	
	10	50	235·			11	17	54·	
	14	39	55·			15	7	234·	
12	9	47	235·		30	10	15	54·	
	13	37	55·			14	5	234·	
13	8	45	235·		31	9	13	54·	
	12	35	55·			13	2	234·	
	16	24	235·		Nov. 1	8	10	54·	
14	7	43	235·			12	0	234·	26·8
	11	32	55·			15	50	54·	
	15	22	235·		2	7	8	54·	
15	6	41	235·			10	58	234·	
	10	30	55·			14	47	54·	
	14	20	235·		3	6	6	54·	
16	9	28	55·			9	56	234·	
	13	18	235·			13	45	53·	
17	8	26	55·		4	8	53	233·	
	12	15	235·			12	43	53·	
18	7	23	55·			16	32	233·	
	11	13	235·		5	7	51	233·	
	15	3	55·			11	41	53·	
19	6	21	55·			15	30	233·	
	10	11	235·		6	6	49	233·	
	14	0	55·			10	38	53·	
20	9	9	235·			14	28	233·	
	12	58	55·		7	5	47	233·	26·8
21	8	6	235·			9	36	53·	
	12	16	55·			13	26	233·	
	15	46	235·		8	8	34	53·	
22	7	4	235·			12	24	233·	
	10	54	55·	26·0		16	13	53·	
	14	43	235·		9	7	32	53·	
23	9	51	54·			11	21	233·	
	13	41	234·			15	11	53·	
24	8	49	54·		10	10	19	233·	
	12	39	234·			14	9	53·	
	16	28	54·		11	9	17	232·	
25	7	47	54·			13	6	52·	
	11	37	234·			16	56	232·	
	15	26	54·		12	8	15	232·	
26	6	45	54·			12	4	52·	
	10	34	234·			15	54	232·	
	14	24	54·		13	7	12	232·	
27	9	32	234·			11	2	52·	
	13	22	54·		14	10	0	52·	26·2
						13	49	232·	

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *American Association.*—The twenty-eighth annual meeting of the American Association for the Advancement of Science was held at Saratoga, during the week from August 27th to September

3d. The President of the meeting was Professor George F. Barker of Philadelphia; the Vice Presidents, Professor S. P. Langley of Alleghany and Major J. W. Powell of Washington; the chairman of the Sub-section of Chemistry, Professor Ira Remsen of Baltimore, and of that of Microscopy, Professor E. W. Morley of Hudson, Ohio.

The officers of the local Committee were Dr. R. C. McEwen, Dr. J. L. Perry, Professor H. N. Wilson, Lt. Commander A. R. McNair, Professor L. S. Packard. They with the other gentlemen associated with them were highly successful in their arrangements for everything connected with the main purpose of the Association, as well as for the comfort and entertainment of the members. Under their auspices excursions were taken to Luzerne, to Lake George, to the Ausable Chasm, to Port Henry, and to other points of interest.

Of the various addresses delivered in the evenings, first to be mentioned is that of the retiring President, Professor O. C. Marsh, on the "History and Methods of Palæontological Discovery." This will be printed in the next number of this Journal. Other addresses were delivered by the Vice Presidents S. P. Langley and J. W. Powell on Friday evening, August 29; Saturday, August 30, by Dr. T. A. Edison on the "Electro-chemical Telephone."

The next meeting is to be held at Boston on the last Wednesday in August, 1880. The officers appointed for the meeting are: President, Lewis H. Morgan of Rochester; Vice President of Section A, Professor Asaph Hall of Washington; Vice President of Section B, Professor Alexander Agassiz of Cambridge; Chairman of Sub-section C, John M. Ordway of Boston; Chairman of Sub-section E, Major J. W. Powell of Washington.

The following is a list of papers which were read or accepted for reading in the different sections.

I. *Mathematics, Astronomy and Physics.*

Experimental Determination of the velocity of light, A. A. MICHELSON.

The comet of 1771: investigation of its orbit, W. BEEBE.

Some observations on the depth of snow compared with the depth of the water it yields, J. BROCKLESBY.

Statement of generalization reached in question in intersection of circles and intersection of spheres: results stated, not the geometrical discussion, B. ALVORD.

Meteoric constitution of the sidereal universe: I. Cooling of the sun, B. PIERCE.—II. Cooling of the earth, id.

On a curious case of crystallization of Canada balsam, G. F. BARKER.—On the conversion of mechanical energy into heat by magneto-electric machines, id.

A general law indicating the location of planets, satellites, or annular rings around their primaries; also its utility, S. MARSDEN.

On experimental solution of a problem in the doctrine of chances, T. C. MENDENHALL.

Solubility of ozone, A. R. LEEDS.

Modification of the glass-plate polarimeter, A. W. WRIGHT.—Influence of light on the electrical conductivity of metals, id.

On the use of glass circles for meridian instruments and of glass bars for standards of length, W. A. ROGERS.—First results from a new diffraction ruling engine, id.—On a standard meter and its subdivisions into equal parts. id.—On the coefficient of expansion of nickel-plated bars, id.—On the tremors communicated to transit piers and clock piers through the walls of an observatory building, id.

Observations of double stars, ASAPH HALL.

Star places, LEWIS BOSS.—Solar parallax from minor planets at opposition, id.

On determination of errors of form of the pivots of meridian instruments, C. A. YOUNG.

On the color correction of achromatic telescopes, WM. HARKNESS.

The past state of the world's metrology as bearing on the progress of science, F. A. P. BARNARD.

New methods of Photometry as applied to electric light, P. H. VAN DER WEYDE.

A table of remainders of 2^n to various prime moduli, E. P. AUSTIN.

On the identity of the lines of Oxygen with bright solar lines, as shown in photographs taken with increased dispersion, HENRY DRAPER.

On a trigonometrical view of the calculus, J. TROWBRIDGE.

On a resonant tuning fork, T. A. EDISON.—On the phenomena of heating metal in vacuo by means of an electric current, id.

A surface upon which the "non-euclidean geometry" finds its interpretation, A. W. PHILLIPS.

Test of faradic machines, F. R. UPTON.

Upon the methods of exploring the field of induction of flat spirals, A. G. BELL.—Upon residual induction, id.—Upon binaural audition, id.

Observations of the transit of Mercury, 1878, May 6, including a systematic search for a satellite, and measures of the diameter of the planet, D. P. TODD.

On the strength of American timber, R. H. THURSTON.

On explosive and detonating compounds, B. S. HEDRICK.

A study: forms of energy, J. D. WARNER.

II. *Chemistry.*

Action of ozone upon the coloring matter of plants, A. R. LEEDS.—Bleaching of sugar syrups by ozone, id.—Reduction of carbonic acid by phosphorus at ordinary temperatures, id.—Oxidation of carbonic acid by air over phosphorus at ordinary temperatures, id.

Household chemistry, ELLEN H. RICHARDS.

On the deterioration of library bindings, W. R. NICHOLS.—Observations on the variations in the temperature and chemical characters of Fresh Pond, Mass., id.—On an accidental contamination of a source of water supply, id.

Percentage of sugar in sap of the sugar maple, H. M. WILEY.—A modified method of collecting and measuring gases soluble in water, id.

Details of the construction of an apparatus for the analysis of gases, E. W. MORLEY.—Results of systematic analyses of air, designed to discover the cause of variations in the quantity of oxygen therein contained, id.

Preliminary notice of the revision of the atomic weights, F. W. CLARKE.

On graphite from the Ducktown copper mine, W. L. DUDLEY and F. W. CLARKE.

Method of coloring, cutting and polishing agates, etc., at Oberstein, Mrs. E. A. SMITH.

Note on a peculiar case of corrosion of the metal tin, J. W. OSBORNE.

On the limits of meteorological conditions governing the extension of beet root culture, W. MCMURTRIE.

On the action of caustic alkaline solution on glass, A. A. BRENEMAN.

A chemical examination of black ozokerite, C. G. WHEELER.

Exhibition of crystals of sapphire from the gem beds of Ceylon, with brief remarks, A. C. HAMLIN.

III. *Geology, Zoology, Botany.*

The succession of glacial deposits in New England, W. UPHAM.

On the thinning and absence of Upper Silurian and Devonian formation in Tennessee, J. M. SAFFORD.

Recently discovered cupreous veins at Blue Hill, Me., C. H. HITCHCOCK.

On the histology of insects, C. S. MINOT.—On the conditions to be fulfilled by a theory of life, id.—On the anatomy of Plathelminths, id.

A short biography of the Menhaden, G. BROWNE GOODE.

On the fertilization of Yucca, T. MEEHAN.

Philosophy of the pupation of butterflies, and particularly of the Nymphalidæ, C. V. RILEY.—The cotton worm in the United States, explanation of its work, and mooted points in its habits cleared up, id.

Homologies in the Lauraceæ, L. F. WARD.—Sexual differentiation in *Epigæa repens*, id.—Note on the movement of the stamens of Sabbatia angularis, id.

On a remarkable crinoidal form recently discovered in Tennessee, with exhibition of specimens, J. M. SAFFORD.

The fauna of the Lower Helderberg group, in relation of the Corals, Bryozoa and Echinodermata, JAMES HALL.—Notes upon the genera Fenestella, Hemitrypa, etc., id.—On the present condition of the work upon the palæontology of New York, id.

On some pre-Cambrian rocks in America and Europe, T. STERRY HUNT.—On the geology of Port Henry. N. Y., id.

The newly discovered cave in Luray, Page Co., Va., J. W. CHICKERING, Jr.

Gypsum sand, A. P. S. STUART.

The interoceanic canal problem, E. P. LULL.

On the progress of the second geological survey of Pennsylvania, J. P. LESLIE.

Notice of the occurrence of rocks representing the Marcellus shales of New York in Central Ohio, R. P. WHITFIELD.

Objects of sex and of odor in flowers, T. MEEHAN.

On the genus Pleurotomaria, W. H. DALL.—On the molluscan dredgings in the Gulf of Mexico and vicinity by the U. S. Coast Survey steamer Blake in 1877–9, id.

On the species of Bornean Orangs, with notes on their habits, illustrated by specimens, W. F. HORNADAY.

On the occurrence of microscopic crystals in the vertebra of the toad (*Bufo Americanus*). [With a note by A. A. Julien.] H. C. BOLTON.

On the anthracite coal fields of Pennsylvania and their rapid exhaustion, P. W. SHEAFER.

The development of the neuration in the wings of insects, as illustrated in the history of cockroaches, S. H. SCUDDER.

The bud-blight insect, W. S. BARNARD.

An apparatus for photographing natural history objects in a horizontal position, S. H. GAGE.—A method of demonstrating the thoracic duct in animals, id.—The inter-articular ligaments of the head of the ribs in the cat, id.

A new form of unpolarizable electrodes for physiological research, H. P. BOWDITCH.

A successful moth-trap, W. S. BARNARD.

Colors and defective vision, D. G. CROLY.

Some new or little known anatomical and physiological instruments and apparatus, B. G. WILDER.—Notes on the anatomy of the cat's brain, id.—On a cat's brain with the *corpus callosum* absent, id.

Some interesting insect habits and their development, W. S. BARNARD.

On certain forms of Muscæ Volitantes, J. W. OSBORNE.

On the Triassic rocks of New Jersey, G. H. COOK.

The Green Mountain anticlinal, C. H. HITCHCOCK.

On the geology of Bermuda, W. NORTH RICE.

The geological action of the Acid of Humus: I. On unconsolidated deposits. II. On solid rocks, A. A. JULIEN.

The genesis of the Serpentine of Reichenstein, etc., R. B. HARE.

On the surface limits of thickness of the continental glacier, in New Jersey, J. C. SMOCK.

IV. *Anthropology.*

The ethnical influences of physical geography, D. WILSON.

Archæological notes from Japan, E. S. MORSE.

Description of a polished stone implement found in Monkton, Vt., J. M. CURRIER.

The substances amber and jade, illustrated by remarkable specimens, Mrs. E. A. SMITH.

On the explanation of hereditary transmission, LOUIS ELSBERG.

The Ethnology of the islands of the Indian and Pacific oceans; illustrated by a large colored map, A. S. BICKMORE.

The sign language of the North American Indians, GARRICK MALLERY.

On some large and remarkable stone implements of the southern mound builders, F. W. PUTNAM.—On the pottery of the southern mound builders, id.

Superstitions among the ancient inhabitants of the Mississippi valley relative to the owl, to the rabbit, to serpents, to thunder, J. G. HENDERSON.—Lake Erie and the Eries, id.

Exhibition of archæological objects, S. S. HALDEMAN.

Archæology of Champlain valley, giving a general account of recent discoveries, G. H. PERKINS.

Consonantal expression of emotion, C. J. BLAKE.

2. *British Association.*—The meeting of the British Association—the forty-ninth—was held at Sheffield during the week from August 20th to August 28th. The exercises were opened on Wednesday evening, the 20th, by the Inaugural Address of the President, Professor G. J. Allman; devoted to "an account of the most generalized expression of living matter, and of the more recent investigations into its nature and phenomena." The attendance was not very large, but the papers were numerous and excited much interest; on the whole the meeting is described as having been one of decided success. The first of the evening discourses was delivered by Mr. W. Crookes upon Radiant Matter. It was illustrated by a large number of remarkably beautiful and brilliant experiments, performed on so large a scale that they were visible to an audience of nearly two thousand persons—this lecture forms the opening article in the present number of this Journal. The next meeting of the Association is to be held at Swansea, with Professor A. R. Ramsay as President. The meeting of the following year, 1881, is appointed for York.

3. *A Treatise on Hygiene and Public Health:* edited by ALBERT H. BUCK, M.D. 2 vols. 8vo. pp. 792, 657. New York, 1879. (William Wood & Co.)—This treatise consists of a series of twenty-five essays specially prepared by nearly as many contributors, most of whom are already known as specialists in various departments of sanitary science, medicine or surgery, or who are officers of boards of health. The essays treat of such special subjects as Infant Hygiene, Foods and Drinks, Food Adulterations, Water and Water Supply, Ventilation, Drainage and Sewerage in their sanitary aspects, the Hygiene of occupations, of camps and of marine service, Hospital Construction, Public Health, Vital Statistics, Public Nuisances, Disinfectants, Quarantine, etc., suitably edited and arranged.

As would be inferred the essays are of different degrees of excellence and completeness, and the treatise in a measure combines the characters of a hand-book of hygiene and a cyclopedia of sanitary science. As a whole, the work is well done. Some of the papers are particularly good; several of them are supplemented with a bibliography of the subject, and most of them are adapted to popular as well as professional readers. The treatise is a valuable contribution to sanitary literature in that it is a presentation of the subjects in the light of our present knowledge, by recognized authorities. W. H. B.

THE

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[THIRD SERIES.]

ART. XLI.—*History and Methods of Palæontological Discovery;* by O. C. MARSH.

[Presidential Address before the American Association for the Advancement of Science, at Saratoga, New York, August 28, 1879.]

IN the rapid progress of knowledge, we are constantly brought face to face with the question, What is Life? The answer is not yet, but a thousand earnest seekers after truth seem to be slowly approaching a solution. This question gives a new interest to every department of science that relates to life in any form, and the history of life offers a most suggestive field for research. One line of investigation lies through embryology, and here the advance is most encouraging. Another promising path leads back through the life history of the globe, and in this direction we may hope for increasing light, as a reward for patient work.

The plants and animals now living on the earth interest alike the savage and the savant, and hence have been carefully observed in every age of human history. The life of the remote past, however, is preserved only in scanty records, buried in the earth, and therefore readily escapes attention. For these reasons, the study of ancient life is one of the latest of modern sciences, and among the most difficult. In view of the great advances which this department of knowledge has made within the last decade, especially in this country, I have thought it fitting to the present occasion to review briefly its development, and have chosen for my subject this evening, THE HISTORY AND METHODS OF PALÆONTOLOGICAL DISCOVERY.

In the short time now at my command, I can only attempt to present a rapid sketch of the principal steps in the progress of this science. The literature of the subject, especially in connection with the discussions it provoked, is voluminous, and an outline of the history itself must suffice for my present purpose.

In looking over the records of Palæontology, its history may conveniently be divided into four periods, well marked by prominent features, but, like all stages of intellectual growth, without definite boundaries.

The first period, dating back to the time when men first noticed fossil remains in the rocks, and queried as to their nature, is of special historic interest. The most prominent characteristic of this period was, a long and bitter contest as to the *nature of fossil remains*. Were they mere "sports of Nature," or had they once been endowed with life? Simple as this problem now seems, centuries passed before the wise men of that time were agreed upon its solution.

Sea shells in the solid rock on the tops of mountains early attracted the attention of the ancients, and the learned men among them seem to have appreciated in some instances their true character, and given rational explanations of their presence.

The philosopher Zenophanes, of Colophon, who lived about 500 B. C., mentions the remains of fishes and other animals in the stone quarries near Syracuse; the impression of an anchovy in the rock of Paros, and various marine fossils at other places. His conclusion from these facts was, that the surface of the earth had once been in a soft condition at the bottom of the sea; and thus the objects mentioned were entombed. Herodotus, half a century later, speaks of marine shells on the hills of Egypt, and over the Libyan desert, and he inferred therefrom that the sea had once covered that whole region. Empedocles, of Agrigentum (450 B. C.), believed that the many hippopotamus bones found in Sicily were remains of human giants, in comparison with which the present race were as children. Here, he thought, was a battle field between the gods and the Titans, and the bones belonged to the slain. Pythagoras (582 B. C.) had already anticipated one conclusion of modern geology, if the following statement, attributed to him by Ovid, was his own:*

Vidi ego quod fuerat solidissima tellus,
Esse fretum: vidi factas ex æquore terras;
Et procul a pelago conchæ jacuere marinæ.

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* Metamorphoses, Liber XV, 262.

Aristotle (384–322 B. C.) was not only aware of the existence of fossils in the rocks, but has also placed on record sagacious views as to the changes in the earth's surface necessary to account for them. In the second book of his Meteorics, he says: "The changes of the earth are so slow in comparison to the duration of our lives, that they are overlooked; and the migrations of people after great catastrophes and their removal to other regions, cause the event to be forgotten." Again, in the same work, he says: "As time never fails, and the universe is eternal, neither the Tanais, nor the Nile, can have flowed for ever. The places where they rise were once dry, and there is a limit to their operations: but there is none to time. So of all other rivers; they spring up, and they perish; and the sea also continually deserts some lands and invades others. The same tracts, therefore, of the earth are not, some always sea, and others always continents, but everything changes in the course of time."

Aristotle's views on the subject of spontaneous generation were less sound, and his doctrines on this subject exerted a powerful influence for the succeeding twenty centuries. In the long discussion that followed concerning the nature of fossil remains, Aristotle's views were paramount. He believed that animals could originate from moist earth or the slime of rivers, and this seemed to the people of that period a much simpler way of accounting for the remains of animals in the rocks than the marvelous changes of sea and land otherwise required to explain their presence. Aristotle's opinion was in accordance with the Biblical account of the creation of Man out of the dust of the earth, and hence more readily obtained credence.

Theophrastus, a pupil of Aristotle, alludes to fossil fishes found near Heraclea, in Pontus, and in Paphlagonia, and says: "They were either developed from fish spawn left behind in the earth, or gone astray from rivers or the sea into cavities of the earth, where they had become petrified." In treating of fossil ivory and bones, the same writer supposed them to be produced by a certain plastic virtue latent in the earth. To this same cause, as we shall see, many later authors attributed the origin of all fossil remains.

Previous to this, Anaximander, the Miletian philosopher, who was born about 610 years before Christ, had expressed essentially the same view. According to both Plutarch and Censorinus, Anaximander taught that fishes, or animals very like fishes, sprang from heated water and earth, and from these animals came the human race; a statement which can hardly be considered as anticipating the modern idea of evolution, as some authors have imagined.

The Romans added but little to the knowledge possessed by the Greeks in regard to fossil remains. Pliny (23–79 A. D), however, seems to have examined such objects with interest, and in his renowned work on Natural History gave names to several forms. He doubtless borrowed largely from Theophrastus, who wrote about three hundred years before. Among the objects named by Pliny were, "*Bucardia*, like to an ox's heart;" "*Brontia*, resembling the head of a tortoise, supposed to fall in thunder storms;" "*Glossoptra*, similar to a human tongue, which does not grow in the earth, but falls from heaven while the moon is eclipsed;" "the *Horn of Ammon*, possessing, with a golden color, the figure of a ram's horn;" *Ceraunia* and *Ombria*, supposed to be thunderbolts; *Ostracites*, resembling the oyster shell; *Spongites*, having the form of sponge; *Phycites*, similar to sea-weed or rushes. He also mentions stones resembling the teeth of hippopotamus; and says that Theophrastus speaks of fossil ivory, both black and white, of bones born in the earth, and of stones bearing the figure of bones.

Tertullian (160 A. D.) mentions instances of the remains of sea animals on the mountains, far from the sea, but uses them as a proof of the general deluge recorded in Scripture.

During the next thirteen or fourteen centuries, fossil remains of animals and plants seemed to have attracted so little attention, that few references are made to them by the writers of this period. During these ages of darkness, all departments of knowledge suffered alike, and feeble repetitions of ideas derived from the ancients seem to have been about the only contributions of that period to Natural Science.

Albert the Great (1205–1280 A. D.), the most learned man of his time, mentions that a branch of a tree was found, on which was a bird's nest containing birds, the whole being solid stone. He accounted for this strange phenomenon by the *vis formativa* of Aristotle, an occult force, which, according to the prevalent notions of the time, was capable of forming most of the extraordinary objects discovered in the earth.

Alexander *ab Alexandro*, of Naples, states that he saw, in the mountains of Calabria, a considerable distance from the sea, a variegated hard marble, in which many sea shells but little changed were heaped, forming one mass with the marble.

With the beginning of the sixteenth century, a great impetus was given to the investigation of organic fossils, especially in Italy, where this study really began. The discovery of fossil shells, which abound in this region, now attracted great attention, and a fierce discussion soon arose as to the true nature of these and other remains. The ideas of Aristotle in regard to spontaneous generation, and especially his view of the hidden forces of the earth, which he claimed had power to produce such remains, now for the first time were seriously questioned, although it was not till nearly two centuries later that these doctrines lost their dominant influence.

Leonardo da Vinci, the renowned painter and philosopher, who was born in 1452, strongly opposed the commonly accepted opinions as to the origin of organized fossils. He claimed that the fossil shells under discussion were what they seemed, and had once lived at the bottom of the sea. "You tell me," he says, "that Nature and the influence of the stars have formed these shells in the mountains; then show me a place in the mountains where the stars at the present day make shelly forms of different ages, and of different species in the same place." Again, he says, "In what manner can such a cause account for the petrifactions in the same place of various leaves, seaweeds, and marine crabs?"

In 1517, excavations in the vicinity of Verona brought to light many curious petrifactions, which led to much speculation as to their nature and origin. Among the various authors who wrote on this subject was Fracastoro, who declared that the fossils once belonged to living animals, which had lived and multiplied where found. He ridiculed the prevailing ideas that the plastic force of the ancients could fashion stones into organic forms. Some writers claimed that these shells had been left by Noah's flood, but to this idea Fracastoro offered a mass of evidence, which would now seem conclusive, but which then only aroused bitter hostility. That inundation, he said, was too transient; it consisted mainly of fresh water; and if it had transported shells to great distances, must have scattered them over the surface, not buried them in the interior of mountains.

Conrad Gesner (1516–1565), whose history of animals has been considered the basis of modern zoology, published at Zurich in 1565 a small but important work entitled "*De omni rerum fossilium genere.*" It contained a catalogue of the collection of fossils made by John Kentmann. This is the oldest catalogue of fossils with which I am acquainted.

George Agricola (1494–1555) was, according to Cuvier, the first mineralogist who appeared after the revival of learning in Europe. In his great work, "*De Re Metallica,*" published in 1546, he mentions various fossil remains, and says they were produced by a certain "*materia pinguis,*" or fatty matter, set in fermentation by heat. Some years later, Bauhin published a descriptive catalogue of the fossils he had collected in the neighborhood of Boll, in Wurtemberg.*

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* *Historia novi et admirabilis Fontis Balneique Bollensis, in Ducatu Wirtembergico. Montbéliard*, 1598.

Andrew Mattioli, a distinguished botanist, adopted Agricola's notion as to the origin of organized fossils, but admitted that shells and bones might be turned into stone by being permeated by a "lapidifying juice." Falloppio, the eminent professor of anatomy at Padua, believed that fossil shells were generated by fermentation where they were found; and that the tusks of elephants, dug up near Apulia, were merely earthy concretions. Mercati, in 1574, published figures of the fossil shells preserved in the Museum of the Vatican, but expressed the opinion that they were only stones, that owed their peculiar shapes to the heavenly bodies. Olivi, of Cremona, described the fossils in the Museum at Verona, and considered them all "sports of nature."

Palissy, a French author, in 1580, opposed these views, and is said to have been the first to assert in Paris that fossil shells and fishes had once belonged to marine animals. Fabio Colonna appears to have first pointed out that some of the fossil shells found in Italy were marine, and some terrestrial.

Another peculiar theory discussed in the sixteenth century deserves mention. This was the vegetation theory, especially advocated by Tournefort and Camerarius, both eminent as botanists. These writers believed that the seeds of minerals and fossils were diffused throughout the sea and the earth, and were developed into their peculiar forms by the regular increment of their particles, similar to the formation of crystals. "How could the *Cornu Ammonis*," Tournefort asked, "which is constantly in the figure of a volute, be formed without a seed containing the same structure in the small, as in the larger forms? Who moulded it so artfully, and where are the moulds?" The stalactites which formed in caverns in various parts of the world were also supposed to be proofs of this vegetative growth.

Still another theory has been held at various times, and is not yet entirely forgotten, namely: that the Creator made fossil animals and plants just as they are found in the rocks, in pursuance of a plan beyond our comprehension. This theory has never prevailed among those familiar with scientific facts, and hence needs here no further consideration.

An interest in fossil remains arose in England later than on the continent; but when attention was directed to them, the first opinions as to their origin were not less fanciful and erroneous than those to which we have already referred. Dr. Plot, in his "Natural History of Oxfordshire," published in 1677, considered the origin of fossil shells and fishes to be due to a "plastic virtue, latent in the earth," as Theophrastus had suggested long before. Lhwyd, in his "*Lithophylacii Britannici Ichnographia*," published at Oxford in 1699, gives a catalogue of English fossils contained in the Ashmolean Museum. He opposed the *vis plastica* theory, and expressed the opinion that the spawn of fishes and other marine animals had been raised with the vapors from the sea, conveyed inland by clouds, and deposited by rain, had permeated into the interior of the earth, and thus produced the fossil remains we find in the rocks. About this time several important works were published in England by Dr. Martin Lister, which did much to infuse a true knowledge of fossil remains. He gave figures of recent shells side by side with some of the fossil forms, so that the resemblance became at once apparent. The fossil species of shells he called "turbinated and bivalve stones," and adds, "either these were terriginous, or, if otherwise, the animals which they so exactly represent have become extinct."

During the seventeenth century there was a considerable advance in the study of fossil remains. The discussions in regard to the nature and origin of these objects, had called attention to them, and many collections were now made, especially in Italy, and also in Germany, where a strong interest in this subject had been aroused. Catalogues of these collections were not unfrequently published, and some of them were illustrated with such accurate figures, that many of the species can now be readily recognized. In this century, too, an important step in advance was made by the collection and description of fossils from particular localities and regions, in distinction from general collections of curiosities.

Casper Schwenkfeld, in 1600, published a catalogue of the fossils discovered in Silesia; in 1622, a detailed description of the renowned Museum of Calceolarius, of Verona, appeared; and in 1642, a catalogue of Besler's collection. Wormius's catalogue was published in 1652; Spener's in 1663; and Septala's in 1666. A description of the Museum of the King of Denmark was issued in 1669; Cottorp's catalogue in 1674; and that of the renowned Kirscher in 1678. Dr. Grew gave an account in 1687 of the specimens in the Museum of Gresham's College in England; and in 1695, Petiver of London published a catalogue of his very extensive collection. A catalogue by Fred. Lauchmund, on the fossils of Hildeshein, appeared in 1669, and the fossils of Switzerland were described by John Jacob Wagner in 1689. Among similar works, were the dissertations of Gyer, at Frankfort, and Albertus, at Leipsic.

Steno, a Dane, who had been professor of anatomy at Padua, published, in 1669, one of the most important works of this period.* He entered earnestly into the controversy as to the origin of fossil remains, and by dissecting a shark from the

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* *De solido intra solidum naturaliter contento.*

Mediterranean, proved that its teeth were identical with some found fossil in Tuscany. He also compared the fossil shells found in Italy with existing species, and pointed out their resemblance. In the same work, Steno expressed some very important views in regard to the different kinds of strata, and their origin, and first placed on record the important fact that the oldest rocks contain no fossils.

Scilla, the Sicilian painter, published in 1670 a work on the fossils of Calabria, well illustrated. He is very severe against those who doubted the organic origin of fossils, but is inclined to consider them relics of the Mosaic deluge.

Another instance of the power of the *lusus naturæ* theory, even at the close of the seventeenth century, deserves mention. In the year 1696, the skeleton of a fossil elephant was dug up at Tonna, near Gotha, in Germany, and was described by William Ernest Tentzel, a teacher in the Gotha Gymnasium. He declared the bones to be the remains of an animal that had lived long before. The Medical Faculty in Gotha, however, considered the subject, and decided officially that this specimen was only a freak of nature.

Beside the authors I have mentioned, there were many others who wrote about fossil remains before the close of the seventeenth century, and took part in the general discussion as to their nature and origin. During the progress of this controversy the most fantastic theories were broached and stoutly defended, and although refuted from time to time by a few clear-headed men, continually sprang up anew, in the same or modified forms. The influence of Aristotle's views of equivocal generation, and especially the scholastic tendency to disputation, so prevalent during the middle ages, had contributed largely to the retardation of progress, and yet a real advance in knowledge had been made. The long contest in regard to the nature of fossil remains was essentially over, for the more intelligent opinion at the time now acknowledged that these objects were not mere "sports of nature," but had once been endowed with life. At this point, therefore, the first period in the history of Palæontology, as I have indicated it, may appropriately end.

It is true that later still, the old exploded errors about the plastic force and fermentation were from time to time revived, as they have been almost to the present day; but learned men, with few exceptions, no longer seriously questioned that fossils were real organisms, as the ancients had once believed. The many collections of fossils that had been brought together, and the illustrated works that had been published about them, were a foundation for greater progress, and, with the eighteenth century, the second period in the history of Palæontology began.

The main characteristic of this period was the general belief, that *fossil remains were deposited by the Mosaic deluge.* We have seen that this view had already been advanced, but it was not till the beginning of the eighteenth century that it became the prevailing view. This doctrine was strongly opposed by some courageous men, and the discussion on the subject soon became even more bitter than the previous one, as to the nature of fossils.

In this diluvial discussion theologians and laymen alike took part. For nearly a century the former had it all their own way, for the general public, then as now, believed what they were taught. Noah's flood was thought to have been universal, and was the only general catastrophe of which the people of that day had any knowledge or conception.

The scholars among them were of course familiar with the accounts of Deucalion and his ark, in a previous deluge, as we are to-day with similar traditions held by various races of men. The firm belief that the earth and all it contains was created in six days; that all life on the globe was destroyed by the deluge, except alone what Noah saved; and that the earth and its inhabitants were to be destroyed by fire, was the foundation on which all knowledge of the earth was based. With such fixed opinions, the fossil remains of animals and plants were naturally regarded as relics left by the flood described in Holy Writ. The dominant nature of this belief is seen in nearly all the literature in regard to fossils published at this time, and some of the works which then appeared have become famous on this account.

In 1710, David Büttner published a volume entitled "*Rudera Diluvii Testes.*" He strongly opposed Lhwyd's explanation of the origin of fossils, and referred these objects directly to the Flood. The most renowned work, however, of this time, was published at Zurich, in 1726, by Scheuchzer, a physician and naturalist, and professor in the University of Altorf. It bore the title "*Homo Diluvii Testis.*" The specimen upon which this work was based was found at Oeningen, and was regarded as the skeleton of a child destroyed by the Deluge. The author recognized in this remarkable fossil, not merely the skeleton, but also portions of the muscles, the liver, and the brain. The same author was fortunate enough to discover, subsequently, near Altorf, two fossil vertebræ, which he at once referred to that "Accursed race destroyed by the Flood!" These, also, he carefully described and figured in his "*Physica Sacra,*" published at Ulm in 1731. Engravings of both were subsequently given in the "Copper-Bible." Cuvier afterward examined these interesting relics, and pronounced the skeleton of the supposed child to be the remains of a gigantic

Salamander, and the two vertebræ to be those of an Ichthyosaurus!

Another famous book appeared in Germany in the same year in which Scheuchzer's first volume was published. The author was John Bartholomew Adam Beringer, professor at the University of Würtzburg, and his great work* indirectly had an important influence upon the investigation of fossil remains. The history of the work is instructive, if only as an indication of the state of knowledge at that date. Professor Beringer, in accordance with views of his time, had taught his pupils that fossil remains, or "figured stones," as they were called, were mere "sports of nature." Some of his fun-loving students reasoned among themselves, "If Nature can make figured stones in sport, why cannot we?" Accordingly, from the soft limestone in the neighboring hills, they carved out figures of marvelous and fantastic forms, and buried them at the localities where the learned Professor was accustomed to dig for his fossil treasures. His delight at the discovery of these strange forms encouraged further production, and taxed the ingenuity of these youthful imitators of Nature's secret processes. At last Beringer had a large and unique collection of forms, new to him, and to science, which he determined to publish to the world. After long and patient study, his work appeared, in Latin, dedicated to the reigning prince of the country, and illustrated with twenty-one folio plates. Soon after the book was published, the deception practiced upon the credulous Professor became known; and, in place of the glory he expected from his great undertaking, he received only ridicule and disgrace. He at once endeavored to repurchase and destroy the volumes already issued, and succeeded so far that few copies of the first edition remain. His small fortune, which had been seriously impaired in bringing out his grand work, was exhausted in the effort to regain what was already issued, as the price rapidly advanced in proportion as fewer copies remained; and, mortified at the failure of his life's work, he died in poverty. It is said that some of his family, dissatisfied with the misfortune brought upon them by this disgrace and the loss of their patrimony, used a remaining copy for the production of a second edition, which met with a large sale, sufficient to repair the previous loss, and restore the family fortune. This work of Beringer, in the end, exerted an excellent influence upon the dawning science of fossil remains. Observers became more cautious in announcing supposed discoveries, and careful study of natural objects gradually replaced vague hypotheses.

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* *Lithographia Wirceburgensis, ducentis lapidum figuratorum, a potiori, insectiformium, prodigiosis imaginibus exornata.* Wirceburgi, 1726. Edit. II. Francofurti et Lipsiae. 1767.

The above works, however, are hardly fair examples of the literature on fossils during this part of the eighteenth century. Scheuchzer had previously published his well-known "Complaint and Vindication of the Fishes," illustrated with good plates. Moro, in his work on "Marine Bodies which are found in the Mountains," 1740, showed the effects of volcanic action in elevating strata, and causing faults. Vallisneri had studied with care the marine deposits of Italy. Donati, in 1750, had investigated the Adriatic, and ascertained by soundings that shells and corals were being imbedded in the deposits there, just as they were found in the rocks.

John Gesner's dissertation, "*De Petrificatis*," published at Leyden in 1758, was a valuable contribution to the science. He enumerated the various kinds of fossils, and the different conditions in which they are found petrified, and stated that some of them, like those at Oeningen, resembled the shells, fishes, and plants of the neighboring region, while others, such as Ammonites and Belemnites, were either unknown species, or those found only in distant seas. He discusses the structure of the earth at length, and speculates as to the causes of changes in sea and land. He estimates that, at the observed rate of recession of the ocean, to allow the Appenines, whose summits are filled with marine shells, to reach their present height, would have taken about eighty thousand years, a period more than "ten times greater than the age of the universe." He accordingly refers the change to the direct command of the Deity, as related by Moses, that, "The waters should be gathered together in one place, and the dry land appear."

Voltaire (1694–1778), discussed geological questions and the nature of fossils in several of his works, but his published opinions are far from consistent. He ridiculed effectively and justly the cosmogonists of his day, and showed, also, that he knew the true nature of organic remains. Finding, however, that theologians used these objects to confirm the Scriptural account of the deluge, he changed his views, and accounted for fossil shells found in the Alps, by suggesting that they were Eastern species, dropped by the pilgrims on their return from the Holy Land!

Buffon, in 1749, published his important work on Natural History, and included in it his "Theory of the Earth," in which he discussed, with much ability, many points in Geology. Soon after the book was published, he received an official letter from the Faculty of Theology in Paris, stating that fourteen propositions in his works were reprehensible, and contrary to the creed of the church. The first objectionable proposition was as follows: "The waters of the sea have produced the mountains and valleys of the land,—the waters of the heavens reducing all to a level, will at last deliver the whole land over to the sea, and the sea successively prevailing over the land, will leave dry new continents like those we inhabit."

Buffon was politely requested by the college to recant, and having no particular desire to be a martyr to science, submitted the following declaration, which he was required to publish in his next work: "I declare that I had no intention to contradict the text of Scripture; that I believe most firmly all therein related about the creation, both as to order of time and matter of fact; and I abandon everything in my book respecting the formation of the earth, and, generally, all which may be contrary to the narration of Moses."

This single instance will suffice to indicate one great obstacle to the advancement of science, even up to the middle of the eighteenth century.

Another important work appeared in France about this time, Bourguet's "*Traité des Pétrifactions*," published in 1758, which is well illustrated with faithful plates. In England, a discourse on earthquakes, by Dr. Robert Hooke, was published in 1705. This author held some views in advance of his time, and maintained that figured stones were "really the several bodies they represent or the moldings of them petrified, and not, as some have imagined, a *lusus naturæ*, sporting herself in the needless formation of useless things." He anticipates one important conclusion from fossils, when he states that "though it must be very difficult to read them and to raise a chronology out of them, and to state the intervals of time wherein such or such catastrophes and mutations have happened, yet it is not impossible." He also states that fossil turtles, and such large Ammonites as are found in Portland, seem to have been the productions of hotter countries, and hence it is necessary to suppose that England once lay under the sea within the torrid zone. He seems to have suspected that some of the fossils of England belonged to extinct species, but thought they might possibly be found living in the bottom of distant oceans.

Dr. Woodward's "Natural History of the Fossils of England" appeared in 1729. This work was based on a systematic collection of fossils which he had brought together, and which he subsequently bequeathed to the University of Cambridge, where it is still preserved, with his arrangement carefully retained. This descriptive part of this work is interesting, but his conclusions are made to coincide strictly with the Scriptural account of the creation and deluge. He had previously stated, in another work, that he believed, "the whole terrestrial globe to have been taken to pieces and dissolved at the flood, and the strata to have settled down from this promiscuous mass." In support of this view, he stated that, "Marine bodies are lodged in the strata according to the order of their gravity, the heavier shells in stones, the lighter in chalk, and so of the rest."*

The most important work on fossils published in Germany at this time, was that of George Wolfgang Knorr, which was continued after his death by Walch. This work consisted of four folio volumes, with many plates, and was printed at Nuremberg, 1755–73. A large number of fossils were accurately figured and described, and the work is one of permanent value.† A French translation of this work appeared in 1767–78. Burton's "*Oryctographie de Bruxelles*," 1784, contains figures and descriptions of fossils found in Belgium.

Abraham Gottlieb Werner (1750–1817), Professor of Mineralogy at Freyberg, did much to advance the science of Geology, and indirectly, that of fossils. He first indicated the relations of the main formations to each other, and, according to his pupil, Professor Jameson, first made the highly important observation "that different formations can be discriminated by the petrifactions they contain." Moreover, "that the petrifactions contained in the oldest rocks are very different from any of the species of the present time; that the newer the formation, the more do the remains approach in form to the organic beings of the present creation." Unfortunately, Werner published little, and his doctrines were mainly disseminated by his enthusiastic pupils.

The great contest between the Vulcanists and the Neptunists started at this time, mainly through Werner, whose doctrines led to the controversy. The comparative merits of fire and water, as agencies in the formation of certain rocks, were discussed with a heat and acrimony characteristic of the subject and the time. Werner believed in the aqueous theory, while the igneous theory was especially advocated by Hutton of Edinburgh, and his illustrator, Playfair. This discussion resulted in the advancement of descriptive geology, but the study of fossils gained little thereby.

The "*Protogæa*" of Leibnitz, the great mathematician, published in 1749, about thirty years after his death, was a work of much merit. This author supposed that the earth had gradually cooled from a state of igneous fusion, and was subsequently covered with water. The subsidence of the lower part of the earth, the deposits of sedimentary strata from inundations, and their induration, as well as other changes, followed. All this, he supposed to have been accomplished in a period of six natural days. In the same work Leibnitz shows that he had examined fossils with considerable care.

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* Essay towards a Natural History of the Earth. 1695.

† *Lapides ex celeberr. viror. sententia diluvii universalis testes, quos in ordines ac species distribuit, suis coloribus expremit, etc.* 272 Tab. 1755–73.

Linnæus (1707–1778), the famous Swedish botanist, and the founder of the modern system of nomenclature in Natural History, confined his attention almost entirely to the living forms. Although he was familiar with the literature of fossil remains, and had collected them himself, he did not include them in his system of plants and animals, but kept them separate, with the minerals; hence he did little directly to advance this branch of science.

During the last quarter of the eighteenth century, the belief that fossil remains were deposited by the Deluge sensibly declined, and the dawn of a new era gradually appeared. Let us pause for a moment here, and see what real progress had been made; what foundation had been laid on which to establish a science of fossil remains.

The true nature of these objects had now been clearly determined. They were the remains of animals and plants. Most of them certainly were not the relics of the Mosaic Deluge, but had been deposited long before, part in fresh water and part in the sea. Some indicated a mild climate, and some the tropics. That any of these were extinct species, was as yet only suspected. Large collections of fossils had now been made, and valuable catalogues, well illustrated, had been published. Something was known, too, of the geological position of fossils. Steno, long before, had observed that the lowest rocks were without life. Lehmann had shown that above these primitive rocks, and derived from them, were the secondary strata, full of the records of life; and above these were alluvial deposits, which he referred to local floods, and the Deluge of Noah. Rouelle, Fuchsel, and Odoardi had shed new light on this subject. Werner had distinguished the transition rocks, containing fossil remains, between the primitive and the secondary, while everything above the chalk he grouped together, as the "overflowed land." Werner, as we have seen, had done more than this, if we give him the credit his pupils claim for him. He had found that the formations he examined contained each its own peculiar fossils, and that from the older to the newer there was a gradual approach to recent forms. William Smith had worked out the same thing in England, and should equally divide the honor of this important discovery.

The greatest advance, however, up to this time, was that men now preferred to *observe*, rather than to *believe*, and facts were held in greater esteem than vague speculations. With this preparation for future progress, the second period in the history of Palæontology, as I have divided it, may appropriately be considered at an end.

Thus far, I have said nothing in regard to one branch of my subject, the *methods* of Palæontological research, for up to this time, of method there was none. We have seen that those of the ancients who noticed marine shells in the solid rock, called them such, and concluded that they had been left there by the sea. The discovery of fossils led directly to theories of how the earth was formed. Here the progress was slow. Subterranean spirits were supposed to guard faithfully the mysteries of the earth; while above the earth, Authority guarded with still greater power the secrets men in advance of their age sought to know. The dominant idea of the first sixteen centuries of the present era was, that the universe was made for Man. This was the great obstacle to the correct determination of the position of the earth in the universe, and, later, of the age of the earth. The contest of Astronomy against authority was long and severe, but the victory was at last with science. The contest of Geology against the same power followed, and continued almost to our day. The result is still the same. In the early stages of this contest, there was no strife, for science was benumbed by the embrace of superstition and creed, and little could be done till that was cast off. In a superstitious age, when every natural event is referred to a supernatural cause, science cannot live; and often as the sacred fire may be kindled by courageous far-seeing souls, will it be quenched by the dense mists of ignorance around it. Scarcely less fatal to the growth of science is the age of Authority, as the past proves too well. With freedom of thought, came definite knowledge, and certain progress;—but two thousand years was long to wait.

With the opening of the present century, began a new era in Palæontology, which we may here distinguish as the third period in its history. This branch of knowledge became now a science. Method replaced disorder, and systematic study superseded casual observation. For the next half century the advance was continuous, and rapid. One characteristic of this period was, *the accurate determination of fossils by comparison with living forms.* This will separate it from the two former epochs. Another distinctive feature of this period was the general belief that, *every species, recent and extinct, was a separate creation.*

At the very beginning of the epoch we are now to consider, three names stand out in bold relief: Cuvier, Lamarck, and William Smith. To these men, the science of palæontology owes its origin. Cuvier and Lamarck, in France, had all the power which great talent, education, and station could give; William Smith, an English surveyor, was without culture or influence. The last years of the eighteenth century had been spent by each of these men in preparation for his chosen work, and the results were now given to the world. Cuvier laid the foundation of the palæontology of Vertebrate animals; Lamarck, of the Invertebrates; and Smith established the principles of Stratigraphical Palæontology. The investigator of fossils to-day seldom needs to consult earlier authors of the science.

George Cuvier (1769–1832), the most famous naturalist of his time, was led to the study of extinct animals by ascertaining that the remains of fossil elephants he examined were extinct species. "This idea," he says later, "which I announced to the Institute in the month of January 1796, opened to me views entirely new respecting the theory of the earth, and determined me to devote myself to the long researches and to the assiduous labors which have now occupied me for twenty-five years."*

It is interesting to note here that in this first investigation of fossil vertebrates, Cuvier employed the same method that gave him such important results in his later researches. Remains of elephants had been known to Europe for centuries, and many authors, from Pliny down to the contemporaries of Cuvier, had written about them. Some had regarded the bones as those of human giants, and those who recognized what they were considered them remains of the elephants imported by Hannibal or the Romans. Cuvier, however, compared the fossils directly with the bones of existing elephants, and proved them to be distinct. The fact that these remains belonged to extinct species was of great importance. In the case of fossil shells, it was difficult to say that any particular form was not living in a distant ocean; but the two species of existing elephants, the Indian and the African, were well known, and there was hardly a possibility that another living one would be found.

It is important to bear in mind, too, that Cuvier's preparation for the study of the remains of animals was far in advance of any of his predecessors. He had devoted himself for years to careful dissections in the various classes of the animal kingdom, and was really the founder of comparative anatomy, as we now understand it. Cuvier investigated the different groups of the whole kingdom with care, and proposed a new classification founded on the plan of structure, which in its main features is the one in use to-day. The first volume of his Comparative Anatomy appeared in 1800, and the work was completed in five volumes in 1805.

Previous to Cuvier, the only general catalogue of animals was contained in Linnæus' "*Systema Naturæ.*" In this work, as we have seen, fossil remains were placed with the Minerals, not in their appropriate places among the animals and plants.

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* *Ossemens Fossiles*, Second Edition, Vol. I, p. 178.

Cuvier enriched the animal kingdom by the introduction of fossil forms among the living, bringing all together into one comprehensive system. His great work, "*Le Règne Animal*," appeared in four volumes, in 1817, and with its two subsequent editions remains the foundation of modern zoology. Cuvier's classic work on vertebrate fossils—"*Recherches sur les Ossemens Fossiles*," in four volumes, appeared in 1812–13. Of this work, it is but just to say that it could only have been written by a man of genius, profound knowledge, the greatest industry, and with the most favorable opportunities.

The introduction to this work was the famous "Discourse on the Revolutions of the Surface of the Globe," which has perhaps been as widely read as any other scientific essay. The discovery of fossil bones in the gypsum quarries of Paris, by the workmen, who considered them human remains; the careful study of these relics by Cuvier, and his restorations from them of strange beasts that had lived long before, is a story with which you are all familiar. Cuvier was the first to prove that the earth had been inhabited by a succession of different series of animals, and he believed that those of each period were peculiar to the age in which they lived.

In looking over his work after a lapse of three-quarters of a century, we can now see that Cuvier was wrong on some important points, and failed to realize the direction in which science was rapidly tending. With all his knowledge of the earth, he could not free himself from tradition, and believed in the universality and power of the Mosaic deluge. Again, he refused to admit the evidence brought forward by his distinguished colleagues against the permanence of species, and used all his great influence to crush out the doctrine of evolution, then first proposed. Cuvier's definition of a species, the dominant one for half a century, was as follows: "A species comprehends all the individuals which descend from each other, or from a common parentage, and those which resemble them as much as they do each other."

The law of "Correlation of Structures," as laid down by Cuvier, has been more widely accepted than almost any thing else that bears his name; and yet, although founded in truth, and useful within certain limits, it would certainly lead to serious error if applied widely in the way he proposed.

In his Discourse, he sums this law as follows: "A claw, a shoulder blade, a condyle, a leg or arm bone, or any other bone separately considered, enables us to discover the description of teeth to which they have belonged; so also reciprocally we may determine the form of the other bones from the teeth. Thus, commencing our investigation by a careful survey of any one bone by itself, a person who is sufficiently master of the laws of organic structure, may, as it were, reconstruct the whole animal to which that bone had belonged."

We know to-day that unknown extinct animals cannot be restored from a single tooth or claw, unless they are very similar to forms already known. Had Cuvier, himself, applied his methods to many forms from the early Tertiary or older formations, he would have failed. If, for instance, he had had before him the disconnected fragments of an Eocene Tillodont, he would undoubtedly have referred a molar tooth to one of his Pachyderms; an incisor tooth to a Rodent; and a claw bone to a Carnivore. The tooth of a Hesperornis would have given him no possible hint of the rest of the skeleton, nor its swimming feet the slightest clue to the ostrich-like sternum or skull. And yet, the earnest belief in his own methods led Cuvier to some of his most important discoveries.

Jean Lamarck (1744–1829), the philosopher and naturalist, a colleague of Cuvier, was a learned botanist before he became a zoologist. His researches on the invertebrate fossils of the Paris Basin, although less striking, were not less important than those of Cuvier on the vertebrates; while the conclusions he derived from them form the basis of modern biology. Lamarck's method of investigation was the same, essentially, as that used by Cuvier, namely: a direct comparison of fossils with living forms. In this way, he soon ascertained that the fossil shells imbedded in the strata beneath Paris were, many of them, extinct species, and those of different strata differed from each other. His first memoir on this subject appeared in 1802,* and, with his later works, effected a revolution in conchology. His "System of Invertebrate Animals" appeared the year before, and his famous "*Philosophie Zoologique*," in 1809. In these two works, Lamarck first announced the principles of Evolution. In the first volume of his "Natural History of Invertebrate Animals,"† he gave his theory in detail; and to-day one can only read with astonishment his far-reaching anticipations of modern science. These views were strongly supported by Geoffroy Saint-Hilaire, but bitterly opposed by Cuvier; and their great contest on this subject is well known.

In looking back from this point of view, the philosophical breadth of Lamarck's conclusions, in comparison with those of Cuvier, is clearly evident. The invertebrates on which Lamarck worked offered less striking evidence of change than the various animals investigated by Cuvier; yet they led Lamarck directly to Evolution, while Cuvier ignored what was before him on this point, and rejected the proof offered by others. Both pursued the same methods, and had an abundance of material on which to work, yet the facts observed induced Cuvier to believe in catastrophes; and Lamarck, in the uniform course of nature. Cuvier declared species to be permanent; Lamarck, that they were descended from others. Both men stand in the first rank in science; but Lamarck was the prophetic genius, half a century in advance of his time.

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* *Mémoires sur les fossiles des environs de Paris.* 1802–6.

† *Histoire naturelle des animaux sans vertèbres.* 7 vols. Paris, 1815–1822. 2d edition. 11 vols. 1835–1845.

While the Paris Basin was yielding such important results for Palæontology, its geological structure was being worked out with great care. The results appeared in a volume by Cuvier and Alex. Brongniart, chiefly the work of the latter, published in 1808.* This was the first systematic investigation of Tertiary strata. Three years later, the work was issued in a more extended form. The separate formations were here carefully distinguished by their fossils, the true importance of which for this purpose being distinctly recognized. This advance was not accepted without some opposition, and it is an interesting fact that Jameson, who claimed for Werner the theory here put in practice, rejected its application, and wrote as follows: "To Cuvier and Brongniart we are indebted for much valuable information in their description of the country around Paris, but we must protest against the use they have made of fossil organic remains in their geognostical descriptions and investigations."†

William Smith (1769–1839), "the father of English Geology," had previously published a "Tabular View of the British Strata." He appears to have arrived independently at essentially the same view as Werner in regard to the relative position of stratified rocks. He had determined that the order of succession was constant, and that the different formations might be identified at distant points by the fossils they contained. In his later works, "Strata identified by Organized Fossils," published in 1816–20, and "Stratigraphical System of Organized Fossils," 1817, he gave to the world results of many years of careful investigations on the Secondary formations of England. In the latter work, he speaks of the success of his method in determining strata by their fossils, as follows: "My original method of tracing the strata by the organized fossils imbedded therein, is thus reduced to a science not difficult to learn. Ever since the first written account of this discovery was circulated in 1799, it has been closely investigated by my scientific acquaintances in the vicinity of Bath, some of whom search the quarries of different Strata in that district, with as much certainty of finding the characteristic Fossils of the respective rocks, as if they were on the shelves of their cabinets."

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* *Essai sur la Géographie Minéralogique des environs de Paris.* 4to, 1808.

† Translation of Cuvier's Discourse. Note K. (B.), p. 103, 1817.

The systematic study of fossils now attracted attention in England, also, and was prosecuted with considerable zeal, although with less important results than in France. An extensive work on this subject, by James Parkinson, entitled "Organic Remains of a Former World," was begun in 1804, and completed in three volumes in 1811. A second edition appeared in 1833. This work was far in advance of previous publications in England, and, being well illustrated, did much to make the collection and study of fossils popular. The belief in the geological effects of the Deluge had not yet lost its power, although restricted now to the later deposits; for Parkinson in his later edition wrote as follows: "Why the earth was at first so constituted that the deluge should be rendered necessary—why the earth could not have been at first stored with all those substances, and endued with all those properties which seemed to have proceeded from the deluge—why so many beings were created, as it appears, for the purpose of being destroyed — are questions which I presume not to answer."

William Buckland (1784–1856), published in 1823 his celebrated "*Reliquiæ Diluvianæ*," in which he gave the results of his own observations in regard to the animal remains found in the caves, fissures and alluvial gravels of England. The facts presented are of great value, and the work was long a model for similar researches. Buckland's conclusions were, that none of the human remains discovered in the caves were as old as the extinct mammals found with them, and that the Deluge was universal. In speaking of fossil bones found in the Himalaya mountains, he says: "The occurrence of these bones at such an enormous elevation in the region of eternal snow, and consequently in a spot now unfrequented by such animals as the horse and deer, can, I think, be explained only by supposing them to be of antediluvian origin, and that the carcasses of the animals were drifted to their present place, and lodged in sand, by the diluvial waters."

The foundation of the "Geological Society of London," in 1807, marks an important point in the history of palæontology. To carefully collect materials for future generalizations, was the object in view, and this organization gradually became the centre in Great Britain for those interested in geological science. The society was incorporated in 1826, and has since been the leading organization in Europe for the advancement of the sciences within its field. The Geological Society of France, established at Paris in 1832, and the German Geological Society, founded at Berlin in 1848, have likewise contributed largely to geological investigations in these countries, and to some extent in other parts of the world. In the publications of these three societies, the student of palæontology will find a mine of valuable materials for his work.

The systematic study of fossil Plants may be said to date from the publication of Adolphe Brongniart's "*Prodrome*," in 1828.* This was very soon followed by his larger work, "*Histoire des végétaux fossiles*," issued in 1828–48. Brongniart pursued the same method as Cuvier and Lamarck, viz: the comparison of fossils with living forms, and his results were of great importance. In his "*Tableau des genres végétaux fossiles*," etc., published in Paris in 1849, he gives the classification and distribution of the genera of fossil plants, and traces out the historical progression of vegetable life on the globe, as he had done to a great extent in his previous works. He shows that the cryptogamic forms prevailed in the primary formations; the conifers and cycads in the secondary, and the higher forms in the Tertiary, while four fifths of living plants are exogens.

In England, Lindley and Hutton published, in 1831–37, a valuable work in three volumes, entitled, "Fossil Flora of Great Britain." This work was illustrated by many accurate plates, in which the plants of the coal formation were especially represented. Henry Witham also published two works in 1831 and 1833, in which he treated especially of the internal structure of fossil plants. "Antediluvian Phytology," by Artis, was published in London in 1838. Bowerbank's "History of the Fossil Fruits and Seeds of the London Clay," appeared in 1843. Hooker's memoir "On the Vegetation of the Carboniferous Period as compared with that of the present day," published in 1848, was an important contribution to the science. Bunbury, Williamson, and others, also published various papers on fossil plants. This branch of Palæontology, however, attracted much less attention in England, than on the Continent.

In Germany, the study of fossil plants dates back to the beginning of the century. Von Schlotheim, a pupil of Werner, published in 1804 an illustrated volume on this subject. A more important work was that of Count Sternberg, issued in 1820–38, and illustrated with excellent plates. Cotta in 1832 published a book with the title, "*Die Dendrolithen*," in which he gave the results of his investigations on the inner structure of fossil plants. Von Gutbier in 1835, and Germar in 1844–53, described and figured the plants of two important localities in Germany. Corda's "*Beiträge zur Flora der Vorwelt*," issued at Prague, in 1845, was essentially a continuation of the work of Sternberg. Unger's "*Chloris protogæa*," 1841–45, "*Genera et species plantarum fossilium*," 1850, and his larger work published in 1852, are all standard authorities. In the latter, the theory of descent is applied to the vegetable world. Schimper and Mougeot's "Monograph on the fossil plants of the Vosges," 1845, was well illustrated, and contained noteworthy results.

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* *Prodrome d'une histoire des végétaux fossiles.* 8vo. Paris, 1828.

Göppert, in 1836, published a valuable memoir entitled, "*Systema Filicum Fossilium*," in which he made known the results of his study of fossil ferns. In the same year, this botanist began a series of experiments, in which he attempted to imitate the process of fossilization, as found in nature. He steeped various animal and vegetable substances in waters holding, some calcareous, others siliceous, and others metallic matter in solution. After a slow saturation, the substances were dried, and exposed to heat until the organic matters were burned. In this way Göppert successfully imitated various processes of petrifaction, and explained many things in regard to fossils that had previously been in question. His discovery of the remains of plants throughout the interior of coal did much to clear up the doubts about the formation of that substance. In 1841, Göppert published an important work in which he compared the genera of fossil plants with those now living. In 1852, another extensive work by this author appeared, entitled, "*Fossile Flora des Uebergangs-Gebirges*."

Andræ, Braun, Dunker, Ettinsghausen, Geinitz, and Goldenberg, all made notable contributions to fossil Botany in Germany, during the period we are now considering.

The systematic study of invertebrate fossils, so admirably begun by Lamarck, was continued actively in France. The Tertiary shells of the Seine valley were further investigated by Defrance, and especially by Deshayes, whose great work on this subject was begun in 1824.* DesMoulin's essay on *Sphérulites* in 1826, Blainville's memoir on *Belemnites* in 1827, Férussac's various memoirs on land and fresh water fossil shells, were valuable additions to the subject. A later work of great importance was D'Orbigny's *Paléontologie Française*, 1840–44, which described the mollusca and radiates in detail, according to formations. The other publications of this author are both numerous and valuable. Brongniart and Desmarest's "*Histoire naturelle des Crustacés Fossiles*," published in 1822, is a pioneer work on this subject. Michelins' memoir on the fossil corals of France, 1841–46, was another important contribution to palæontology. Agassiz's works on fossil Echinoderms and Mollusks are valuable contributions to the science. The works of d'Archiac, Coquand, Cotteau, Desor, Edwards, Haime, and De Verneuil, are likewise of permanent value.

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* *Description des coquilles fossiles des environs de Paris.* 3 vols. Paris, 1824–37.

In Italy, Bellardi, Merian, Michellotti, Phillipi, Zigno, and others, contributed important results to Palæontology.

In Belgium, Bosquet, Nyst, Koninck, Ryckholt, Van Beneden, and others, have all aided materially in the progress of the science.

In England, also, invertebrate fossils were studied with care, and continued progress was made. Sowerby's "Mineral Conchology of Great Britain," in six volumes, a systematic work of great value, was published in 1812–30, and soon after was translated into French and German. Its figures of fossil shells are excellent, and it is still a standard work. Miller's "Natural History of the Crinoidea," published at Bristol, in 1821, and Austin's later monograph, are valuable for reference. Brown's "Fossil Conchology of Britain and Ireland" appeared in 1839, and Brodie's History of the Fossil Insects of England, in 1845. Phillips' illustration of the geology of Yorkshire, 1829–36, and his work on the Palæozoic fossils of Cornwall, Devonshire, and West Somerset, 1843, contained a great deal of original matter in regard to fossil remains. Morris' "Catalogue of British Fossils," issued in 1843, and the later edition in 1854, is most useful to the working palæontologist. The memoirs of Davidson on the Brachiopoda, Edwards, Forbes, Morris, Lycett, Sharpe, and Wood on other Mollusca, Wright on the Echinoderms, Salter on Crustacea, Busk on Polyzoa, Jones on the Entomostraca, and Duncan and Lonsdale on Corals, are of especial value. King's volume on Permian fossils, Mantell's various memoirs, Dixon's work on the fossils of Sussex, 1850, and McCoy's works on Palæozoic fossils, all deserve honorable mention. Sedgwick, Murchison, and Lyell, although their greatest services were in systematic geology, each contributed important results to the kindred science of palæontology during the period we are reviewing.

In Germany, Schlotheim's treatise, "*Die Petrifactenkunde*," published at Gotha in 1820, did much to promote a general interest in fossils. By far the most important work issued on this subject was the "*Petrifacta Germanica*," by Goldfuss, in three folio volumes, 1826 to 1844, which has lost little of its value. Bronn's "*Geschichte der Natur*," 1841–46, was a work of great labor, and one of the most useful in the literature of this period. The author gave a list of all the known fossil species, with full references, and also their distribution through the various formations. This gave exact data on which to base generalizations, hitherto of comparatively little value.

Among other early works of interest in this department may be mentioned, Dalman's memoir on *Trilobites*, 1828, and Burmeister's on the same subject, 1843. Giebel's well known "*Fauna der Vorwelt*," 1847–1856, gave lists of all the fossils described up to that time, and hence is a very useful work. The "*Lethæa Geognostica*" by Bronn, 1834–38, and the second edition by Bronn and Roemer, 1846–56, is a comprehensive general treatise on Palæontology, and the most valuable work of the kind yet published.

The researches of Ehrenberg, in regard to the lowest forms of animals and plants, threw much light on various points in Palæontology, and showed the origin of extensive deposits, the nature of which had before been in doubt. Von Buch, Barrande, Beyrich, Berendt, Dunker, Geinitz, Heer, Hörnes, Klipstein, Von Münster, Reuss, Roemer, Sandberger, Suess, Von Hagenow, Von Hauer, Zeiten, and many others, all aided in the advancement of this branch of science. Angelin, Hisinger, and Nilsson, in Scandinavia; Abich, DeWaldheim, Eichwald, Keyserling, Kutorga, Nordmann, Pander, Rouillier, and Volborth, in Russia; and Pusch in Poland, published important results on fossil invertebrates.

The impetus given by Cuvier to the study of vertebrate fossils extended over Europe, and great efforts were made to continue discoveries in the direction he had so admirably pointed out.

Louis Agassiz (1807–73), a pupil of Cuvier, and long an honored member of this association, attained eminence in the study of ancient as well as of recent life. His great work on Fossil Fishes* deserves to rank next to Cuvier's "*Ossemens Fossiles*." The latter contained mainly fossil mammals and reptiles, while the fishes were left without a historian till Agassiz began his investigations. His studies had admirably fitted him for the task, and his industry brought together a vast array of facts bearing on the subject. The value of this grand work consists not only in its faithful descriptions and plates, but also in the more profound results it contained. Agassiz first showed that there is a correspondence between the succession of fishes in the rocks, and their embryonal development. This is now thought to be one of the strongest points in favor of evolution, although its discoverer interpreted the facts as bearing the other way.

Pander's memoirs on the fossil fishes of Russia form a worthy supplement to Agassiz's classic work. Brandt's publications are likewise of great value; and those of Lund, in Sweden, have an especial interest to Americans, in consequence of his researches in the caves of Brazil.

Croizet and Jobert's "*Recherches sur les ossemens fossiles du départment du Puy-de-Dôme*," published in 1828, contained valuable results in regard to fossil mammals. Geoffroy St. Hilaire's researches on fossil Reptiles, published in 1831, were an important advance. De Serres and De Christol's explorations in the caverns in the South of France, published between 1829 and 1839, were of much value. Schmerling's researches in the caverns of Belgium, published in 1833–36, were especially important on account of the discovery of human remains mingled with those of extinct animals. Deslongchamp's memoirs on fossil reptiles, 1835, are still of great interest. Pictet's general treatise on palæontology was a valuable addition to the literature, and has done much to encourage the study of fossils.* DeBlainville, in his grand work, "*Ostéographie*," issued in 1839–56, brought together the remains of living and extinct vertebrates, forming a series of the greatest value for study. Aymard and Pomel's contributions to vertebrate Palæontology are both of value. Gervais and Lartet added much to our knowledge of the subject, and Bravard and Hébert's memoirs are well known.

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* *Recherches sur les Poissons fossiles*, 1833–45.

The brilliant discoveries of Cuvier in the Paris Basin, excited great interest in England, and when it was found that the same Tertiary strata existed in the south of England, careful search was made for vertebrate fossils. Remains of some of the same genera described by Cuvier were soon discovered, and other extinct animals new to science were found in various parts of the kingdom. König, to whom we owe the name *Ichthyosaurus*, and Conybeare, who gave the generic designation *Plesiosaurus*, and also *Mosasaurus*, were among the earliest writers in England on fossil reptiles. The discovery of these three extinct types, and the discussion as to their nature, forms a most interesting chapter in the annals of Palæontology. The discovery of the *Iguanodon*, by Mantell, and the *Megalosaurus*, by Buckland, excited still higher interest. These great reptiles differed much more widely from living forms than the mammals described by Cuvier, and the period in which they lived soon became known as the "age of Reptiles." The subsequent researches of these authors added largely to the existing knowledge of various extinct forms, and their writings did much to arouse public interest in the subject.

Richard Owen, a pupil of Cuvier, followed, and brought to bear upon the subject an extensive knowledge of comparative anatomy, and a wide acquaintance with existing forms. His contributions have enriched almost every department of palæontology, and of extinct vertebrates especially, he has been, since Cuvier, the chief historian. The fossil reptiles of

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* "*Traité élémentaire de paléontologie*," etc., *Genève*. 4 vols. 1844–46. Second Edition. Paris, 1853–55.

England, he has systematically described, as well as those of South Africa. The extinct Struthious birds of New Zealand, he has made known to science, and accurately described in extended memoirs. His researches on the fossil mammals of Great Britain, the extinct Edentates of South America, and the ancient Marsupials of Australia, each forms an important chapter in the history of our science.

The personal researches of Falconer and Cautley in the Sewalik Hills of India brought to light a marvelous vertebrate fauna of Pliocene age. The remains thus secured were made known in their great work, "*Fauna Antiqua Sivalensis,*" published at London in 1845. The important contributions of Egerton to our knowledge of fossil fishes, and Jardine's well known work, "Ichnology of Annandale," also belong to this period.

The study of vertebrate fossils in Germany was prosecuted with much success during the present period. Blumenbach, the ethnologist, in several publications between 1803 and 1814, recorded valuable observations on this subject. In 1812, Sömmerring gave an excellent figure of a pterodactyle, which he named and described. Goldfuss' researches on the fossil vertebrates from the Caves of Germany, published in 1820–23, made known the more important facts of that interesting fauna. His later publications on extinct Amphibians and Reptiles were also noteworthy. Jäger's investigations on the extinct vertebrate fauna of Wurtemberg, published between 1824 and 1839, were an important advance. To Plieninger's researches in the same region, 1834–44, we owe the discovery of the first Triassic mammal (*Microlestes*), as well as important information in regard to Labyrinthodonts. Kaup's researches on fossil mammals, 1832–41, brought to light many interesting forms, and to him we are indebted for the generic name *Dinotherium*, and excellent descriptions of the remains then known.

Count Münster's "*Beiträge zur Petrifacten-Kunde,*" published 1843–46, contained several valuable papers on fossil vertebrates; and the separate papers by the same author are of interest. Andreas Wagner wrote on Pterosaurians in 1837, and later gave the first description of fossil mammals of the Tertiary of Greece, 1837–40. Johannes Müller published an important illustrated work on the Zeuglodonts, in 1849, and various notable memoirs; and Quenstedt, interesting descriptions of fossil reptiles, as well as other papers of much value. Rütimeyer's suggestive memoirs are widely known.

Hermann von Meyer's contributions to vertebrate palæontology are by far the most important published in Germany during the period we are now considering. From 1830, his investigations on this subject were continuous for nearly forty years, and his various publications are all of value. His "*Beiträge zur Petrifactenkunde,*" 1831–33, contains a series of valuable memoirs. His "*Palæologica,*" issued in 1832, includes a synopsis of the fossil vertebrates then known, with much original matter. His great work, "*Zur Fauna der Vorwelt,*" 1845–60, includes a series of monographs invaluable to the student of vertebrate palæontology. This work, as well as his other chief publications, was illustrated with admirable plates from his own drawings. Other memoirs by this author will be found in the "*Palæontographica,*" of which he was one of the editors. In the many volumes of this publication, which began in 1851, and is still continued, will be found much to interest the investigator in any branch of palæontology.

The "Palæontographical Society of London," established in 1847, has also issued a series of volumes containing valuable memoirs in various branches of Palæontology. These two publications together are a storehouse of knowledge in regard to extinct forms of animal and vegetable life.

It may be interesting here to note briefly the use of general terms in Palæontology, as the gradual progress of the science was indicated to some extent in its terminology. At first, and for a long time, the name "*fossil*" was appropriately used for objects dug from the earth, both minerals and organic remains. The term "Oryctology," having essentially the same meaning, was also used for this branch of study. For a long period, too, the termination *ites* (λίϑος, a stone) was applied to fossils to distinguish them from the corresponding living forms; as, for instance, "*Ostracites,*" used by Pliny. At a later date, the general name "figured stones" (*lapides figurati*) was extensively used; and less frequently, "Deluge stones" (*lapides diluviani*). The term "organized fossils" was used to distinguish fossils from minerals, when the real difference became known, although the name "*Reliquiæ*" was sometimes employed. The term "petrifactions" (*Petrificata*) was defined by John Gesner in his work on fossils in 1758, and was afterwards extensively used. Palæontology is comparatively a modern term, having come into use only within the last half century. It was introduced about 1830, and soon was generally adopted in France and England; but in Germany it met with less favor, though used to some extent.

It would be interesting, too, did time permit, to trace the various opinions and superstitions, held at different times, in regard to some of the more common fossils, for example, the Ammonite, or the Belemnite. Of their supposed celestial origin; of their use as medicine by the ancients, and in the East to-day; of their marvellous power as charms, among the Romans, and still among the American Indians. It would be instructive, also, to compare the various views expressed by students in science, concerning some of the stranger extinct forms, for instance, the Nummulites, among Protozoa; the Rudistes, among Mollusks; or the Mosasaurus, among Reptiles. Dissimilar as such views were, they indicate in many cases gropings after truth,—natural steps in the increase of knowledge.

The third period in the history of Palæontology, which, as I have said, began with Cuvier and Lamarck at the beginning of the present century, forms a natural epoch extending through six decades. The definite characteristics of this period, as stated, were dominant during all this time, and the progress of Palæontology was commensurate with that of intelligence and culture.

For the first half of this period, the marvelous discoveries in the Paris Basin excited astonishment, and absorbed attention; but the real significance and value of the facts made known by Cuvier, Lamarck, and William Smith, were not appreciated. There was still a strong tendency to regard fossils merely as interesting objects of natural history, as in the previous period, and not as the key to profounder problems in the earth's history. Many prominent geologists were still endeavoring to identify formations in different countries by their mineral characters, rather than by the fossils imbedded in them. Such names as "Old Red Sandstone," and "New Red Sandstone," were given in accordance with this opinion. Humboldt, for example, attempted to compare the formations of South America and Europe by their mineral features, and doubted the value of fossils for this purpose. In 1823, he wrote as follows: "Are we justified in concluding that all formations are characterized by particular species? that the fossil shells of the chalk, the muschelkalk, the Jura limestone, and the Alpine limestones, are all different? I think this would be pushing the induction much too far."* Jameson still thought minerals more important than fossils for characterizing formations; while Bakewell, later yet, defines Palæontology as comprising "Fossil Zoology and Fossil Botany, a knowledge of which may appear to the student as having little connection with Geology."

During the later half of the third period, greater progress was made, and before its close Geology was thoroughly established as a science. Let us consider for a moment what had really been accomplished up to this time.

It had now been proved beyond question that portions at least of the Earth's surface had been covered many times by the sea, with alternations of fresh water and of land; that the strata thus deposited were formed in succession, the lowest of the series being the oldest; that a distinct succession of animals and plants had inhabited the earth during the different geological periods; and that the order of succession found in one part of the earth was essentially the same in all. More than 30,000 new species of extinct animals and plants had now been described. It had been found, too, that from the oldest formations to the most recent, there had been an advance in the grade of life, both animal and vegetable, the oldest forms being among the simplest, and the higher forms successively making their appearance.

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* *Essai géognostique sur le gisement des Roches*, p. 41.

It had now become clearly evident, moreover, that the fossils from the older formations were all extinct species, and that only in the most recent deposits were there remains of forms still living. The equally important fact had been established, that in several groups of both animals and plants, the extinct forms were vastly more numerous than the living; while several orders of fossil animals had no representatives in modern times. Human remains had been found mingled with those of extinct animals, but the association was regarded as an accidental one by the authorities in science; and the very recent appearance of Man on the earth was not seriously questioned. Another important conclusion reached, mainly through the labors of Lyell, was, that the earth had not been subjected in the past to sudden and violent revolutions; but the great changes wrought had been gradual, differing in no essential respect from those still in progress. Strangely enough, the corollary to this proposition, that Life, too, had been continuous on the earth, formed at that date no part of the common stock of knowledge.

In the physical world, the great law of "Correlation of forces" had been announced, and widely accepted; but in the organic world, the dogma of the miraculous creation of each separate species still held sway, almost as completely as when Linnæus declared: "There are as many different species as there were different forms created in the beginning by the Infinite Being." But the dawn of a new era was already breaking, and the third period of palæontology we may consider now at an end.

Just twenty years ago, science had reached a point when the belief in "special creations" was undermined by well established facts, slowly accumulated. The time was ripe. Many naturalists were working at the problem, convinced that Evolution was the key to the present and the past. But how had Nature brought this change about? While others pondered, Darwin spoke the magic word—"*Natural Selection*," and a new epoch in science began.

The fourth period in the history of Palæontology dates from this time, and is the period of to-day. One of the main characteristics of this epoch is the belief that *all life, living and extinct, has been evolved from simple forms.* Another prominent feature is the accepted fact of *the great antiquity of the human race.* These are quite sufficient to distinguish this period sharply from those that preceded it.

The publication of Charles Darwin's work on the "Origin of Species," November, 1859, at once aroused attention, and started a revolution which has already in the short space of two decades changed the whole course of scientific thought. The theory of "Natural Selection," or as Spencer has happily termed it, the "Survival of the Fittest," had been worked out independently by Wallace, who justly shares the honor of the discovery. We have seen that the theory of Evolution was proposed and advocated by Lamarck, but he was before his time. The anonymous author of the "Vestiges of Creation," which appeared in 1844, advocated a somewhat similar theory which attracted much attention, but the belief that species were immutable was not sensibly affected until Darwin's work appeared.

The difference between Lamarck and Darwin is essentially this: Lamarck proposed the theory of Evolution; Darwin changed this into a doctrine, which is now guiding the investigations in all departments of biology. Lamarck failed to realize the importance of time, and the interaction of life on life. Darwin, by combining these influences with those also suggested by Lamarck, has shown *how* the existing forms on the earth may have been derived from those of the past.

This revolution has influenced Palæontology as extensively as any other department of science, and hence the new period we are discussing. In the last epoch, species were represented independently, by parallel lines; in the present period, they are indicated by dependent, branching lines. The former was the analytic, the latter is the synthetic, period. To-day, the animals and plants now living are believed to be genetically connected with those of the distant past; and the palæontologist no longer deems species of the first importance, but seeks for relationships and genealogies, connecting the past with the present. Working in this spirit, and with such a method, the advance during the last decade has been great, and is an earnest of what is yet to come.

The progress of Palæontology in Great Britain during the present period has been great, and the general interest in the science much extended. The views of Darwin soon found acceptance here. Next to his discovery of "Natural Selection," Darwin was fortunate in having so able and bold an expounder as Huxley; who was one of the first to adopt his theory, and give it a vigorous support. Huxley's masterly researches have been of great benefit to all departments of Biology, and his contributions to Palæontology are invaluable. Among the latter, his original investigations on the relations of Birds and Reptiles are especially noteworthy. His various memoirs on extinct Reptiles, Amphibians and Fishes, belong to the permanent literature of the subject. The important researches of Owen on the fossil vertebrates have been continued to the present time. He has added largely to his previous publications on the British fossil Reptiles, Birds, and Mammals; the extinct reptiles of South Africa, and the Post-Tertiary birds of New Zealand. His description of the *Archæopteryx* near the beginning of the period was a most welcome contribution.

The investigations of Egerton on Fossil Fishes have likewise been continued with important results. Busk, Dawkins, Flower and Sanford have made valuable contributions to the history of fossil Mammals. Bell, Günther, Hulke, Lankester, Powrie, Miall, and Seely, have made notable additions to our knowledge of Reptiles, Amphibians, and Fishes. Among Invertebrates, the Crustacea have been especially studied by Jones, Salter, and Woodward. Davidson, Etheridge, Lycett, Morris, Phillips, Wood, and Wright have continued their researches on the Mollusks; Duncan, Nicholson and others have investigated the extinct Corals; and Binney, Carruthers, and Williamson, the Fossil Plants. Numerous other important contributions have been made to the science in Great Britain during the present period.

On the Continent, the advance in Palæontology has, during the last two decades, been equally great. In France, Gervais continued his memoirs on extinct vertebrates nearly to the present date; while Gaudry has published several volumes on the subject that are models for all students of the science. His work on the fossil animals of Greece is a perfect monograph of its kind, and his later publications are all of importance. Lartet's various works are of permanent value, and his application of Palæontology to Archæology brought notable results. The volume of Alphonse Milne-Edwards on fossil Crustacea was a fit supplement to Brongniart and Desmarest's well known work; while his grand memoir on fossil Birds deserves to rank with the classic volumes of Cuvier. Duvernoy, Filhol, Hébert, Sauvage and others have also published interesting results on fossil vertebrates.

Van Beneden's researches on the fossil vertebrates of Belgium have produced results of great value. Pictet, Rütimeyer, and Wedersheim in Switzerland, Bianconi, Forsyth-Major, and

Sismonda in Italy, and Nodot in Spain, have likewise published important memoirs. The extinct vertebrates have been studied in Germany by Von Meyer, Carus, Fraas, Giebel, Haeckel, Haase, Hensel, Kayser, Kner, Ludwig, Peters, Portis, Maack, Salenka, Zittel, and many others; in Holland by Winkler, in Denmark by Reinhardt; and in Russia by Brandt and Kowalewsky.

The fossil invertebrates have been investigated with care by D'Archiac, D'Orbigny, Bayle, Fromentel, Oustalet, and others in France; Desor, Loriol and Roux in Switzerland; Cappellini, Massalongo, Michellotti, Meneghini, and Sismonda in Italy, Barrande, Benecke, Beyrich, Dames, Dorn, Ehlers, Geinitz, Giebel, Gümbel, Feistmantel, Hagen, von Hauer, von Heyden, von Fritsch, Laube, Oppel, Quenstedt, Roemer, Schlüter, Suess, Speyer, and Zittel in Germany. The fossil Plants have been studied in these countries by Massalongo, Saporta, Zigno, Fiedler, Goldenberg, Gehler, Heer, Goeppert, Ludwig, Schimper, Schenk, and many others.

Among the recent researches in Palæontology in other regions may be mentioned those of Blanford, Feistmantel, Lydekker, and Stoliczka, in India; Haast and Hector in New Zealand, and Krefft and McCoy in Australia; all of whom have published valuable results.

Of the progress of palæontology in America, I have thus far said nothing, and I need now say but little, as many of you are doubtless familiar with its main features. During the first and second periods in the history of palæontology, as I have defined them, America, for most excellent reasons, took no part. In the present century, during the third period, appear the names of Bigsby, Green, Morton, Mitchell, Rafinesque, Say, and Troost, all of whom deserve mention. More recently, the researches of Conrad, Dana, Deane, DeKay, Emmons, Gibbes, Hitchcock, Holmes, Lea, McChesney, Owen, Redfield, Rogers, Shumard, Swallow, and many others, have enlarged our knowledge of the fossils of this country.

The contributions of James Hall to the Invertebrate Palæontology of this country form the basis of our present knowledge of the subject. The extensive labors of Meek in the same department are likewise entitled to great credit, and will form an important chapter in the history of the science. The memoirs of Billings, Gabb, Scudder, White, and Whitfield are numerous and important; and the publications of Derby, Hartt, James, Miller, Shaler, Rathburn, and Winchell, are also of value. To Dawson, Lesquereux, and Newberry, we mainly owe our present knowledge of the fossil plants of this country.

The foundation of our vertebrate Palæontology was laid by Leidy, whose contributions have enriched nearly every department of the subject. The numerous publications of Cope are well known. Agassiz, Allen, Baird, Dawson, Deane, DeKay, Emmons, Gibbes, Harlan, Hitchcock, Jefferson, Lea, LeConte, Newberry, Redfield, St. John, Warren, Whitney, Worthen, Wyman, and others, have all added to our knowledge of American fossil vertebrates. The chief results in this department of our subject, I have already laid before you on a previous occasion, and hence need not dwell upon them here.

In this rapid sketch of the history of Palæontology, I have thought it best to speak of the earlier periods more in detail, as they are less generally known, and especially as they indicate the growth of the science, and the obstacles it had to surmount. With the present work in palæontology, moreover, you are all more or less familiar, as the results are now part of the current literature. To assign every important discovery to its author, would have led me far beyond my present plan. I have only endeavored to indicate the growth of the science by citing the more prominent works that mark its progress, or illustrate the prevailing opinions and state of knowledge at the time they were written.

In considering what has been accomplished, directly or indirectly, it is well to bear in mind that without palæontology there would have been no science of geology. The latter science originated from the study of fossils, and not the reverse, as generally supposed. Palæontology, therefore, is not a mere branch of geology, but the foundation on which that science mainly rests. This fact is a sufficient excuse, if one were wanting, for noting the early opinions in regard to the changes of the earth's surface, as these changes were first studied to explain the position of fossils. The investigation of the latter first led to theories of the earth's formation, and thus to geology. When speculation replaced observation, fossils were discarded, and for a time the mineral characters of strata were thought to be the key to their position and age. For some time after this, geologists, as we have seen, apologized for using fossils to determine formations, but for the last half century their value for this purpose has been fully recognized.

The services which Palæontology has rendered to Botany and Zoology are less easy to estimate, but are very extensive. The classification of these sciences has been rendered much more complete by the intercalation of many intermediate forms. The probable origin of various living species has been indicated by the genealogies suggested by extinct types; while our knowledge of the geographical distribution of animals and plants at the present day has been greatly improved by the facts brought out in regard to the former distribution of life on the globe.

Among the vast number of new species which have been added are the representatives of a number of new orders entirely unknown among living forms. The distribution of these extinct orders, among the different classes, is interesting, as they are mainly confined to the higher groups. Among the fossil Plants, no new orders have yet been found. There are none known among the Protozoa, or the Mollusca. The Radiates have been enriched by the extinct orders of Blastoidea, Cystidea, and Edrioasterida; and the Crustaceans by the Eurypterida and Trilobita. Among the Vertebrates, no extinct order of fossil Fishes has yet been found; but the Amphibians have been enlarged by the important order Labyrinthodonta. The greatest additions have been among the Reptiles, where the majority of the orders are extinct. Here we have at the present date the Ichthyosauria, Sauranodontia, Plesiosauria and Mosasauria, among the marine forms; the Pterosauria, including the Pteranodontia, containing the flying forms; and the Dinosauria, including the Sauropoda—the giants among reptiles; likewise the Dicynodontia, and probably the Theriodontia, among the terrestrial forms. Although but few fossil Birds have been found below the Tertiary, we have already among the Mesozoic forms three new orders: the Saururæ, represented by *Archæopteryx;* the Odontotormæ, with *Ichthyornis* as the type; and the Odontolcæ, based upon *Hesperornis;* all of these orders being included in the sub-class Odontornithes, or toothed birds. Among Mammals, the new groups regarded as orders are the Toxodontia, and the Dinocerata, among the Ungulates; and the Tillodontia, including strange Eocene Mammals whose exact affinities are yet to be determined.

Among the important results in vertebrate palæontology, are the genealogies, made out with considerable probability, for various existing animals. Many of the larger mammals have been traced back through allied forms in a closely connected series to early Tertiary times. In several cases the series are so complete that there can be little doubt that the line of descent has been established. The Evolution of the horse, for example, is to-day demonstrated by the specimens now known. The demonstration in one case stands for all. The evidence in favor of the genealogy of the horse now rests on the same foundation as the proof that any fossil bone once formed part of the skeleton of a living animal. A special creation of a single bone is as probable as the special creation of a single species. The method of the palæontologist in the investigation of the one, is the method for the other. The only choice lies between natural derivation and supernatural creation.

For such reasons it is now regarded among the active workers in science as a waste of time to discuss the truth of Evolution. The battle on this point has been fought, and won.

The geographical distribution of animals and plants, as well as their migrations, has received much new light from Palæontology. The fossils found in some natural divisions of the earth are related so closely to the forms now living there, that a genetic connection between them can hardly be doubted. The extinct Marsupials of Australia, and the Edentates of South America, are well known examples. The Pliocene hippopotami of Asia and the South of Europe point directly to migrations from Africa. Other similar examples are numerous. The fossil plants of the Arctic region prove the existence of a climate there far milder than at present, and recent researches at least render more probable the suggestion, made long ago by Buffon, in his "Epochs of Nature," that life began in the polar regions, and by successive migrations from them the continents were peopled.

The great services which Comparative Anatomy rendered to Palæontology at the hands of Cuvier, Agassiz, Owen, and others, have been amply repaid. The solution of some of the most difficult problems in Anatomy has received scarcely less aid from the extinct forms discovered, than from Embryology; and the two lines of research supplement each other. Our present knowledge of the vertebrate skull, the limb-arches, and the limbs, has been much enlarged by researches in Palæontology. On the other hand, the recent labors of Gegenbaur, Huxley, Parker, Balfour, and Thacher, will make clear many obscure points in ancient Life.

One of the important results of recent palæontological research, is the law of brain-growth, found to exist among extinct mammals, and to some extent in other vertebrates. According to this law, as I have briefly stated it elsewhere: "All Tertiary mammals had small brains. There was, also, a gradual increase in the size of the brain during this period. This increase was confined mainly to the cerebral hemispheres, or higher portions of the brain. In some groups, the convolutions of the brain have gradually become more complicated. In some, the cerebellum and the olfactory lobes have even diminished in size." More recent researches render it probable that the same general law of brain-growth holds good for birds and reptiles from the Mesozoic to the present time. The Cretaceous birds, that have been investigated with reference to this point, had brains only about one-third as large in proportion as those nearest allied among living species. The Dinosaurs from our Western Jurassic follow the same law, and had brain cavities vastly smaller than any existing reptiles. Many other facts point in the same direction, and indicate that the general law will hold good for all extinct vertebrates.

Palæontology has rendered great service to the more recent science of Archæology. At the beginning of the present period, a re-examination of the evidence in regard to the antiquity of the human race was going on, and important results were soon attained. Evidence in favor of the presence of man on the earth at a period far earlier than the accepted chronology of six thousand years would imply, had been gradually accumulating; but had been rejected from time to time by the highest authorities. In 1823, Cuvier, Brongniart, and Buckland, and later, Lyell, refused to admit that human relics, and the bones of extinct animals found with them, were of the same geological age, although experienced geologists, such as Boué and others, had been convinced by collecting them. Christol, Serres, and Tournal, in France, and Schmerling in Belgium, had found human remains in caves, associated closely with those of various extinct mammals, and other similar facts were on record.

Boucher de Perthes, in 1841, began to collect stone implements in the gravels of the valley of the Somme, and, in 1847, published the first volume of his "*Antiquités Celtiques.*" In this work, he described the specimens he had found, and asserted their great antiquity. The facts as presented, however, were not generally accepted. Twelve years later, Falconer, Evans, and Prestwich examined the same localities with care, became convinced, and the results were published in 1859 and 1860. About the same time Gaudry, Hébert, and Desnoyers, also explored the same valley, and announced that the stone implements there were as ancient as the mammoth and rhinoceros found with them. Explorations in the Swiss lakes and in the Danish shell heaps added new testimony bearing in the same direction. In 1863, appeared Lyell's work on the "Geological Evidences of the Antiquity of Man," in which facts were brought together from various parts of the world, proving beyond question the great age of the human race.

The additional proof since brought to light has been extensive, and is still rapidly increasing. The Quaternary age of man is now generally accepted. Attempts have recently been made to approximate in years the time of man's first appearance on the earth. One high authority has estimated the antiquity of man merely to the last glacial epoch of Europe as

250,000 years; and those best qualified to judge, would, I think, regard this as a fair estimate.

Important evidence has likewise been adduced of man's existence in the Tertiary, both in Europe and America. The evidence to-day is in favor of the presence of man in the Pliocene of this country. The proof offered on this point by Professor J. D. Whitney, in his recent work,* is so strong, and his careful, conscientious method of investigation so well known, that his conclusions seem irresistible. Whether the Pliocene strata he has explored so fully on the Pacific coast corresponds strictly with the deposits which bear this name in Europe, may be a question requiring further consideration. At present, the known facts indicate that the American beds containing human remains, and works of man, are as old as the Pliocene of Europe. The existence of Man in the Tertiary period seems now fairly established.

In looking back over the history of Palæontology, much seems to have been accomplished; and yet the work has but just begun. A small fraction only of the earth's surface has been examined, and two large continents are waiting to be explored. The "imperfection of the geological record," so often cited by friends and foes, still remains, although much improved; but the future is full of promise. In filling out this record, America, I believe, will do her full share, and thus aid in the solution of the great problems now before us.

I have endeavored to define clearly the different periods in the history of Palæontology. If I may venture, in conclusion, to characterize the present period in all departments of science, its main feature would be a *belief in universal laws.* The reign of Law, first recognized in the physical world, has now been extended to Life, as well. In return, Life has given to inanimate nature the key to her profounder mysteries—Evolution, which embraces the universe.

What is to be the main characteristic of the next period? No one now can tell. But if we are permitted to continue in imagination the rapidly converging lines of research pursued to-day, they seem to meet at the point where organic and inorganic nature become one. That this point will yet be reached, I cannot doubt.

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* Auriferous Gravels of the Sierra Nevada of California. 1879.

ART. XLII.—*On the Diamagnetic Constants of Bismuth and Calc-spar in Absolute Measure.*

Part I.—By H. A. ROWLAND, Professor of Physics in the Johns Hopkins University.

SINCE my experiments on the magnetic constants of iron, nickel and cobalt, I have sought the means of determining those of some diamagnetic substances, and to that end have described a method in this Journal for May, 1875, (vol. ix, page 357). As Mr. Jacques, Fellow of the University, was willing to take up the experimental portion, I have here worked up the subject more in detail and brought the formulæ into practical shape. No experiments have been made on this subject so far, but some rough comparisons with iron have been made by Becquerel, Plucker and Weber. But as iron varies so greatly, and as the methods of experiment are inexact, we cannot be said to know much about the subject. As, however, the relative results of these experiments and those of Faraday can be accepted as reasonably exact for diamagnetic substances and weak paramagnetic ones, it is only necessary to make a determination of one substance such as bismuth, and then the rest can be readily found. But as bismuth is very crystalline it is necessary to make our formulæ general, unless we use bismuth in a powder, which would introduce error.

The general method of experiment has been indicated in the paper before referred to, but I may here state that it consists in counting the number of vibrations made by a bar hung in the usual manner between the poles of an electromagnet. The distribution of the magnetic force in the field being known, we can then calculate the force acting on the body, and the comparison of this with the time of vibration gives us the means of determining the constant sought. But I will leave the more exact description to be given by Mr. Jacques in the experimental part.

Exploration of field.

The first operation to be performed is to find a formula to express the force of the field at any point, and an experimental means of determining it in absolute measure. The magnet used was one on the method of Ruhmkorff, and hence the field was nearly symmetrical around the axis of the two branches, and also with respect to a plane perpendicular to the axis at a point midway between its poles. Should any want of symmetry exist by accident, it will be nearly neutralized in its effect on the final result, seeing that the diamagnetic bar hangs symmetrically.

The proper expansion of the magnetic potential for this case is therefore a series of zonal spherical harmonics, including only the uneven powers. Hence, if V is the potential,

$$(1)\qquad V = A_{\prime}Q_{\prime}r + A_{\prime\prime\prime}Q_{\prime\prime\prime}r^3 + A_{\rm v}Q_{\rm v}r^5 + \text{etc.}$$

where r is the distance from the center of symmetry, $Q_{\prime}$, $Q_{\prime\prime\prime}$, etc., are the spherical harmonics with respect to the angle between r and the axis, and $A_{\prime}$, $A_{\prime\prime\prime}$, $A_{\rm v}$, etc., are constants to be found by experiment. The only method known of measuring a strong magnetic field with accuracy is by means of induced currents, and in this case I have used a modification of the method of the proof plane as I have described it in this Journal, III, vol. x, p. 14. In the method there described the coil was to be drawn rapidly away from the given point: in the present case the coil was moved along the axis, thus measuring the difference of the field at several points; on then placing it at the center and drawing it away, the field was measured at that point. The field at the other points along this axis could then be found by adding the measured difference to this quantity. This method is far more accurate than the direct measurement at the different points.

When a wire is moved in a magnetic field the current induced in it is equal to the change of its potential energy, supposing it to transmit a unit current, divided by the resistance of the circuit. The potential energy of a wire in a magnetic field is (Maxwell's Elec., Art. 410),

$$P = \int\left(l\frac{dV}{dx} + m\frac{dV}{dy} + n\frac{dV}{dz}\right)dS$$

which is simply the surface integral of V over any surface whose edge is in the wire.

In the present case, take the axis of x in the direction of the axis of the poles and the surface, S, parallel to the plane YZ, and let ρ be the distance in this plane from the center of the coil we are calculating. Then

$$P = 2\pi\int\frac{dV}{dx}\rho d\rho = \pi\int\frac{dV}{dx}d(\rho^2)$$

for a single circle.

From (1) $$\frac{dV}{dx} = \Sigma_\infty^0 (i+1)A_{i+1}r^iQ_i$$

and $$\rho^2 = x^2\left(\frac{1}{\mu^2} - 1\right);\quad r^i = \frac{x^i}{\mu^i}$$

where $\mu = \cos\theta$

$$\therefore P = -2\pi x^{i+2}\,\Sigma(i+1)A_{i+1}\int_1^\mu \frac{Q_i\,d\mu}{\mu^{i+3}}$$

$$P = 2\pi\rho^2\,\Sigma_\infty^0 A_{i+1}\frac{r^iQ_{i+1}}{i+2}$$

For a circle of rectangular section we must obtain the mean value of this quantity throughout the section of the coil.

$$\therefore \mathrm{M} = \frac{1}{\eta\xi}\int_{x_0-\frac{1}{2}\eta}^{x_0+\frac{1}{2}\eta}\int_{\rho_0-\frac{1}{2}\xi}^{\rho_0+\frac{1}{2}\xi} \mathrm{P}\,dx\,d\rho$$

Where x_0 and ρ_0 are the values of x and ρ at the center of section and η and ξ are the width and depth of the groove in which the coil is wound. We can calculate this quantity best by the formula of Maxwell (Electricity, Art. 700),

$$\mathrm{M} = \mathrm{P}_0 + \tfrac{1}{24}\left(\frac{d^2p_0}{d\rho^2}\xi^2 + \frac{d^2p_0}{dx^2}\eta^2\right) + \text{etc.}$$

Thus we finally find

$$(2)\quad \mathrm{M} = \pi\rho^2\Big\{\mathrm{A}_{\prime}\left(1+\tfrac{1}{12}\frac{\xi^2}{\rho^2}\right)+\tfrac{1}{2}\mathrm{A}_{\prime\prime\prime}r^2_0\left(\mathrm{Q}^1_{\prime\prime\prime}+\tfrac{1}{2}(5\mu^2-3)\frac{\xi^2}{\rho^2}+\tfrac{1}{2}\frac{\eta^2}{\rho^2}(1-\mu^2)\right)$$
$$+\tfrac{1}{8}\mathrm{A}_{\mathrm{v}}\mathrm{Q}^1_{\mathrm{v}}r^4_0 + \text{etc.}\Big\}$$

It is by aid of this equation that we find the coefficients $\mathrm{A}_{\prime}$, $\mathrm{A}_{\prime\prime\prime}$, etc. in the expansion of the magnetic potential, V. For, let the coil be moved in the field from a position where M has the value M′ to where it has the value M″: then if the coil be joined to a galvanometer the current induced will be equal to

$$\frac{\mathrm{M}'-\mathrm{M}''}{\mathrm{R}}$$

where R is the resistance of the circuit. If an earth inductor is included in the circuit whose integral area is E, when it is reversed the current is $\frac{2\mathrm{HE}}{\mathrm{R}}$ where H is the component of the earth's magnetism perpendicular to the plane of the inductor. The current as measured by the galvanometer in the first case will be $\mathrm{C}\sin\frac{1}{2}\delta\,(1+\frac{1}{2}\lambda)$ and in the second $\mathrm{C}\sin\frac{1}{2}\mathrm{D}\,(1+\frac{1}{2}\lambda)$, where C is the constant of the galvanometer and λ is the logarithmic decrement.

Hence

$$\frac{\mathrm{M}'-\mathrm{M}''}{\mathrm{R}} = \mathrm{C}\sin\tfrac{1}{2}\delta\,(1+\tfrac{1}{2}\lambda)$$

$$\frac{2\mathrm{HE}}{\mathrm{R}} = \mathrm{C}\sin\tfrac{1}{2}\mathrm{D}\,(1+\tfrac{1}{2}\lambda)$$

$$\therefore \mathrm{M}'-\mathrm{M}'' = 2\mathrm{HE}\frac{\sin\frac{1}{2}\delta}{\sin\frac{1}{2}\mathrm{D}}$$

In this way we can obtain a series of equations containing $\mathrm{A}_{\prime}$, $\mathrm{A}_{\prime\prime\prime}$, etc., and can thus find these by elimination.

This completes the exploration, and we have as a result a formula giving the magnetic potential of the field in absolute measure throughout a certain small region in which we can experiment.

The next process is to consider the action of this field upon any body which we may hang in it.

Crystalline Body in Magnetic Field.

Let the body have such feeble magnetic action that the magnetic field is not very much influenced by its presence. In all crystalline substances we know there exist in general three axes at right angles to each other, along which the magnetic induction is in the direction of the magnetic force. Let k_1, k_2 and k_3 be the coefficients of magnetization in the directions of these axes and let a set of coördinate axes be drawn parallel to these crystalline axes, the coördinates referred to which are designated by x', y' and z', and the magnetic components of the force parallel to which are X′, Y′ and Z′.

The energy of the crystalline body will then be

$$E = -\tfrac{1}{2}\iiint (k_1 X'^2 + k_2 Y'^2 + k_3 Z'^2)\, dx'dy'dz'$$

In most cases it is more convenient to refer the equation to axes in some other direction through the crystal. Let these axes be X, Y, Z.

Then

$$\begin{aligned} x &= x'\alpha + y'\beta + z'\gamma \\ y &= x'\alpha' + y'\beta' + z'\gamma' \\ z &= x'\alpha'' + y'\beta'' + z'\gamma'' \end{aligned}$$

$$X' = \frac{dV}{dx'} = \frac{dV}{dx}\alpha + \frac{dV}{dy}\alpha' + \frac{dV}{dy}\alpha''$$
$$Y' = \text{etc.}$$

Hence

$$\begin{aligned} X' &= X\alpha + Y\alpha' + Z\alpha'' \\ Y' &= X\beta + Y\beta' + Z\beta'' \\ Z' &= X\gamma + Y\gamma' + Z\gamma'' \end{aligned}$$

where α, β, γ; α', β', γ'; and α'', β'', γ'' are the direction cosines of the new axes with reference to the old.

We then find

$$\begin{aligned} E = -\tfrac{1}{2}\iiint \{ & X^2(k_1\alpha^2 + k_2\beta^2 + k_3\gamma^2) + Y^2(k_1\alpha'^2 + k_2\beta'^2 + k_3\gamma'^2) \\ & + Z^2(k_1\alpha''^2 + k_2\beta''^2 + k_3\gamma''^2) + 2XY(k_1\alpha\alpha' + k_2\beta\beta' + k_3\gamma\gamma') + 2XZ \\ & (k_1\alpha\alpha' + k^2\beta\beta'' + k_3\gamma\gamma'') + 2YZ(k_1\alpha\,\alpha'' + k_2\beta'\beta'' + k_3\gamma'\gamma'') \}\, dx\,dy\,dz \end{aligned}$$

The most simple and in many respects the most interesting cases are when the crystal has only one optic or magnetic axis. In this case $k_2 = k_3$.

Hence

$$E = -\tfrac{1}{2}\iiint \{ (X^2 + Y^2 + Z^2)k_2 + (X\alpha + Y\alpha' + Z\alpha'')^2(k_1 - k_2) \}\, dx\,dy\,dz$$

where α, α' and α'' are the direction cosines of the magnetic axis with respect to the coördinate axes.

The first case to consider is that of a mass of crystal in a uniform magnetic field. The magnetic forces which enter the equation are those due to the magnetic action of the body as well as to the field in which the body is placed. In the case of very weak magnetic or diamagnetic bodies the forces are almost entirely those of the field alone. Hence in the case under consideration we may put $Y=0$ and $Z=0$.

Hence

$$E = -\tfrac{1}{2}\iiint X^2\left((k_1 - k_2)\,\alpha^2 + k_2\right) dx\,dy\,dz,$$

and if v is the volume of the body

$$E = -\tfrac{1}{2}X^2\left((k - k_2)\,\alpha^2 + k_2\right) v$$

As this expression is the same at all points of the field there is no force acting to translate the body from one part of the field to another. The moment of the force tending to increase φ, where $\varphi = \cos^{-1}\alpha$, is

$$-\frac{dE}{d\varphi} = v\,X^2\,(k_1 - k_2)\sin\varphi\cos\varphi$$

By observing the moment of the force which acts on a crystal placed in a uniform magnetic field we can thus find the value of $k_1 - k_2$ or the difference of the magnetic constant along the axis and at right angles to it. The differences of the constants can also be found in the case of crystals with three axes by a similar process.

The next case which I shall consider is that of a bar hanging in a magnetic field. Let the field be symmetrical around an horizontal axis, and also with reference to a plane perpendicular to that axis at the center. If the bar is very long with reference to its section and a plane can be passed through it and the axis we must have $Z=0$, and the equation becomes

$$E = -\tfrac{1}{2}\iiint\left\{(X^2 + Y^2)\,k_2 + (X\alpha + Y\alpha')^2\,(k_1 - k_2)\right\} dx\,dy\,dz$$

Let the axis of X coincide with the long axis of the bar, as this will in the end lead to the most simple result, seeing that we have to integrate along the length of the bar.

Let r be the length along the bar from the center to any point, and let θ be the angle made by the bar with the axis of symmetry: then

$$X = -\frac{dV}{dr} \qquad Y = -\frac{1}{r}\frac{dV}{d\theta}$$

also let the section of the bar be

$$a = dy\,dz$$

and let the axis of the bar pass through the origin from which we have developed the potential in terms of spherical harmonies. We can then write as before

$$V = A_{I}Q_{I}\,r + A_{III}Q_{III}\,r^3 + A_{V}Q_{V}\,r^5 + \text{etc.}$$

where $Q_{,,}$, $Q_{,,,,}$, etc. are zonal spherical harmonies with reference to the angle θ,

$$X = -\{A_{,} Q_{,} + 3A_{,,,} Q_{,,,} r^2 + 5A_{\mathrm{V}} Q_{\mathrm{V}} r^4 + \text{etc.}\}$$

$$Y = +\{A_{,} Q^1_{,} + A_{,,,} Q^1_{,,,} r^2 + A_{\mathrm{V}} Q'_{\mathrm{V}} r^4 + \text{etc.}\} \sin\theta$$

from which we have the following:

$$X^2 = A^2_{,} Q^2_{,} + 9A^2_{,,,} Q^2_{,,,} r^4 + 25A^2_{s} Q^2_{\mathrm{V}} r^8 + 6A_{,} A_{,,,} Q_{,} Q_{,,,} r^2$$
$$+ 10A_{,} A_{\mathrm{V}} Q_{,} Q_{\mathrm{V}} r^4 + 30A_{,,,} A_{\mathrm{V}} Q_{,,,} Q_{\mathrm{V}} r^6 + \text{etc.}$$

$$Y^2 = \{A^2_{,} Q'^2_{,} + A^2_{,,,} Q'^2_{,,,} r^4 + A_{\mathrm{V}} Q'^2_{\mathrm{V}} r^8 + 2A_{,} A_{,,,} Q'_{,} Q'_{,,,} r^2$$
$$+ 2A_{,} A_{\mathrm{V}} Q'_{,} Q'_{\mathrm{V}} r^4 + 2A_{,,,} A_{\mathrm{V}} Q'_{,,,} Q'_{\mathrm{V}} r^6 + \text{etc.}\} \sin^2\theta$$

$$XY = -\{A^2_{,} Q_{,} Q'_{,} + 3A^2_{,,,} Q_{,,,} Q'_{,,,} r^4 + 5A^2_{\mathrm{V}} Q_{\mathrm{V}} Q'_{\mathrm{V}} r^8 + (3Q'_{,} Q_{,,,}$$
$$+ Q_{,} Q'_{,,,}) A_{,} A_{,,,} r^2 + (5Q'_{,} Q_{\mathrm{V}} + Q_{,} Q'_{\mathrm{V}}) A_{,} A_{\mathrm{V}} r^4 + (5Q'_{,,,} Q_{\mathrm{V}}$$
$$+ 3Q_{,,,} Q'_{\mathrm{V}}) A_{,,,} A_{\mathrm{V}} r^6 + \text{etc.}\} \sin\theta$$

The moment of the force tending to increase θ is

$$\Theta = -\frac{dE}{d\theta}$$

whence we may write,

$$\Theta = -\tfrac{1}{2}a\{A\left((k_1 - k_2)\alpha^2 + k_2\right) + B\left((k_1 - k_2)\alpha'^2 + k_2\right) - C(k_1 - k_2)\alpha\alpha'\}$$

where
$$A = -\frac{d}{d\theta}\int_{-l}^{+l} X^2\, dr = \sin\theta \frac{d}{d\mu}\int_{-l}^{+l} X^2\, dr$$

$$B = -\frac{d}{d\theta}\int_{-l}^{+l} Y^2\, dr = \sin\theta \frac{d}{d\mu}\int_{-l}^{+l} Y^2\, dr$$

$$C = -\frac{d}{d\theta}\int_{-1}^{+l} 2XY\, dr = \sin\theta \frac{d}{d\mu}\int_{-1}^{+l} 2XY\, dr$$

where l is half the length of the bar and $\mu = \cos\theta$.

$$A = 4l\sin\theta\{A^2_{,} Q_{,} Q'_{,} + \tfrac{9}{5}A^2_{,,,} Q_{,,,} Q'_{,,,} l^4 + \tfrac{25}{9}A^2_{s} Q_{s} Q'_{s} l^8 + A_{,} A_{,,,}(Q'_{,} Q_{,,,}$$
$$+ Q_{,} Q'_{,,,}) l^2 + A_{,} A_{\mathrm{V}}(Q'_{,} Q_{\mathrm{V}} + Q_{,} Q'_{\mathrm{V}}) l^4 + \tfrac{15}{7}A_{,,,} A_{\mathrm{V}}(Q'_{,,,} Q_{\mathrm{V}} + Q_{,,,} Q'_{\mathrm{V}}) l^6\}$$

$$B = 4l\sin\theta\{A^2_{,}(Q'_{,} Q''_{,} \sin^2\theta - Q'^2_{,} \cos\theta) + A^2_{,,,}(Q'_{,,,} Q''_{,,,} \sin^2\theta$$
$$- Q'^2_{,,,} \cos\theta)\frac{l^4}{5} + A_{\mathrm{V}}(Q'_{\mathrm{V}} Q''_{\mathrm{V}} \sin^2\theta - Q'_{\mathrm{V}} \cos\theta)\frac{l^8}{9} + A_{,} A_{,,,}\Big((Q'_{,} Q''_{,,,}$$
$$+ Q''_{,} Q'_{,,,})\sin^2\theta - 2Q'_{,} Q'_{,,,} \cos\theta\Big)\frac{l^2}{3} + A_{,} A_{\mathrm{V}}\Big((Q'_{,} Q''_{\mathrm{V}} + Q''_{,} Q'_{\mathrm{V}})\sin^2\theta$$
$$- 2Q'_{,} Q'_{\mathrm{V}} \cos\theta\Big)\frac{l^4}{5} + A_{,,,} A_{\mathrm{V}}\Big((Q'_{,,,} Q''_{\mathrm{V}} + Q''_{,,,} Q'_{\mathrm{V}})\sin^2\theta$$
$$- 2Q'_{,,,} Q'_{\mathrm{V}} \cos\theta\Big)\frac{l^6}{7}\Big\}$$

$$C = +4l\{A^2_{,}\left((Q_{,} Q''_{,} + Q'^2_{,})\sin^2\theta - Q_{,} Q'_{,} \cos\theta\right) + 3A^2_{,,,}\Big((Q_{,,,} Q''_{,,,}$$
$$+ Q'^2_{,,,})\sin^2\theta - Q_{,,,} Q'_{,,,} \cos\theta\Big)\frac{l^4}{5} + 5A^2_{\mathrm{V}}\Big((Q_{\mathrm{V}} Q''_{\mathrm{V}} - Q'^2_{\mathrm{V}})\sin^2\theta$$
$$- Q_{\mathrm{V}} Q'_{\mathrm{V}} \cos\theta\Big)\frac{l^8}{9} + A_{,} A_{,,,}\Big((3Q'_{,} Q'_{,,,} + 3Q''_{,} Q_{,,,} + Q'_{,} Q'_{,,,} + Q_{,} Q''_{,,,})\sin^2\theta$$

$$- (3Q'_{,}Q_{,,,} + Q_{,}Q'_{,,,}) \cos\theta\Big)\frac{l^3}{3} + A_{,}A_{\text{v}}\Big((5Q'_{,}Q'_{\text{v}} + 5Q''_{,}Q_{\text{v}}$$
$$+ Q'_{,}Q'_{\text{v}} + Q_{,}Q''_{\text{v}})\sin^2\theta - (5Q'_{,}Q_{\text{v}} + Q_{,}Q'_{\text{v}})\cos\theta\Big)\frac{l^5}{5} + A_{,,,}A_{\text{v}}\Big((5Q''_{,,,}Q_{\text{v}}$$
$$+ 5Q'_{,,,}Q'_{\text{v}} + 3Q'_{,,,}Q'_{\text{v}} + 3Q_{,,,}Q''_{\text{v}})\sin^2\theta - (5Q'_{,,,}Q_{\text{v}}$$
$$+ 3Q_{,,,}Q'_{\text{v}})\cos\theta\Big)\frac{l^9}{9}\Big\}$$

Where

$$\begin{aligned}
Q_{,} &= \cos\theta\\
Q_{,,,} &= \tfrac{1}{2}(5\cos^3\theta - 3\cos\theta)\\
Q_{\text{v}} &= \tfrac{1}{8}(63\cos^5\theta - 70\cos^3\theta + 15\cos\theta)\\
Q'_{,} &= 1\\
Q'_{,,,} &= \tfrac{3}{2}(5\cos^2\theta - 1)\\
Q'_{\text{v}} &= \tfrac{15}{8}(21\cos^4\theta - 14\cos^2\theta + 1)\\
Q''_{,} &= 0\\
Q''_{,,,} &= 15\cos\theta\\
Q''_{\text{v}} &= \tfrac{15}{2}(21\cos^3\theta - 7\cos\theta)\\
\mu &= \cos\theta
\end{aligned}$$

$$A = 4l\sin\theta\{(A^2_{,} + \tfrac{81}{20}A^2_{,,,}l^4 + \tfrac{1875}{192}A^2_{5}l^8 - 3A_{,}A_{,,,}l^2 + \tfrac{15}{4}A_{,}A_{\text{v}}l^4$$
$$- \tfrac{675}{56}A_{,,,}A_{\text{v}}l^6)\mu + (-27A^2_{,,,}l^4 - \tfrac{4375}{24}A^2_{\text{v}}l^8 + 10A_{,}A_{,,,}l^2$$
$$- 35A_{,}A_{\text{v}}l^4 + \tfrac{4275}{28}A_{,,,}A_{\text{v}}l^6)\mu^3 + (\tfrac{135}{4}A^2_{,,,}l^4 + \tfrac{56625}{64}A^2_{\text{v}}l^8$$
$$+ \tfrac{199}{4}A_{,}A_{\text{v}}l^4 - \tfrac{3465}{8}A_{,,,}A_{\text{v}}l^6)\mu^5 + (-\tfrac{6125}{4}A^2_{\text{v}}l^8 + \tfrac{675}{2}A_{,,,}A_{\text{v}}l^6)\mu^7$$
$$+ \tfrac{55125}{64}A^2_{5}l^8\mu^9\}$$

$$B = 4l\sin\theta\{(-A^2_{,} - \tfrac{99}{20}A^2_{,,,}l^4 - \tfrac{725}{64}A^2_{\text{v}}l^8 + 6A_{,}A_{,,,}l^2 - \tfrac{45}{4}A_{,}A_{\text{v}}l^4$$
$$+ \tfrac{225}{14}A_{,,,}A_{\text{v}}l^6)\mu + (\tfrac{63}{2}A^2_{,,,}l^4 - \tfrac{1575}{16}A_{\text{v}}l^8 - 10A_{,}A_{,,,}l^2 + \tfrac{171}{4}A_{,}A_{\text{v}}l^4$$
$$- \tfrac{2475}{14}A_{,,,}A_{\text{v}}l^6)\mu^3 + (-\tfrac{135}{4}A^2_{,,,}l^4 - \tfrac{16275}{32}A^2_{\text{v}}l^8 - \tfrac{189}{4}A_{,}A_{\text{v}}l^4$$
$$+ \tfrac{945}{2}A_{,,,}A_{\text{v}}l^6)\mu^5 + (\tfrac{77425}{48}A^2_{\text{v}}l^8 - \tfrac{675}{2}A_{,,,}A_{\text{v}}l^6)\mu^7 + \tfrac{55125}{64}A_{\text{v}}l^8\mu^9\}$$

$$C = 4l\{(-A^2_{,} - \tfrac{125}{64}A^2_{\text{v}}l^8 - \tfrac{1}{2}A_{,}A_{,,,}l^2 + \tfrac{3}{20}A_{,}A_{\text{v}}l^4 - \tfrac{5}{2}A_{,,,}A_{\text{v}}l^6)$$
$$+ (-\tfrac{3}{2}A_{,}A_{,,,}l^2)\mu + (-\tfrac{297}{20}A^2_{,,,}l^4 - 6A_{,}A_{,,,}l^2 - \tfrac{7}{2}A_{,}A_{\text{v}}l^4$$
$$+ \tfrac{855}{8}A_{,,,}A_{\text{v}}l^6)\mu^2 + 9A_{,}A_{,,,}l^2\mu^3 + (45A^2_{,,,}l^4 + \tfrac{72625}{96}A^2_{\text{v}}l^8$$
$$+ \tfrac{5}{2}A_{,}A_{,,,}l^2 + \tfrac{511}{4}A_{,}A_{\text{v}}l^4 - \tfrac{6485}{12}A_{,,,}A_{\text{v}}l^6)\mu^4 - \tfrac{15}{2}A_{,}A_{,,,}l^2\mu^5$$
$$+ (-\tfrac{99}{4}A^2_{,,,}l^4 - \tfrac{17975}{24}A^2_{\text{v}}l^8 - \tfrac{441}{5}A_{,}A_{\text{v}}l^4 + \tfrac{24815}{48}A_{,,,}A_{\text{v}}l^6)\mu^6$$
$$+ (\tfrac{54125}{192}A^2_{\text{v}}l^8 - \tfrac{7875}{1}A_{,,,}A_{\text{v}}l^6)\mu^8\}$$

Or we can write

$$\begin{aligned}
A &= 4l\sin\theta\{L\mu + L'\mu^3 + L''\mu^5 + \text{etc.}\}\\
B &= 4l\sin\theta\{M\mu + M'\mu^3 + \text{etc.}\}\\
C &= 2l\{N + N'\mu + N''\mu^2\ \text{etc.}\}
\end{aligned}$$

where the values of L, M, etc. are apparent.

To sum up we may then write as before

$$\Theta = -\tfrac{1}{2}a\{A[(k_1 - k_2)\alpha^2 + k_2] + B[(k_1 - k_2)\alpha'^2 + k_2] - C(k_1 - k_2)\alpha\alpha'\}$$

where A, B and C are the quantities we have found, α is the cosine of the angle made by the axis of the crystal with the axis of the bar, and α' is the cosine of the angle made by the same axis with a horizontal line at right angles to the bar.

The equation

$$\Theta = 0$$

gives equilibrium at some angle depending on α and α', and if either of these is zero the angle can be either $\theta = 0$ or $\frac{1}{2}\pi$, one of which will be stable and the other unstable according as the body is para- or dia-magnetic.

For a diamagnetic crystal like bismuth with the axis at right angles to the bar we can put

$$\mu = \cos\theta = \sin\psi \text{ and } \alpha = 0,$$

and we can write

$$\Theta = -\tfrac{1}{2}a\{4lk_2(L\mu + L\mu'^2 + \text{etc.}) + 4l[(k_1 - k_2)\alpha'^2 + k_2][M\mu + M'\mu^3 + \text{etc.}]\}$$

or for very small values of μ we can write in terms of ψ

$$\Theta = -2al\psi\{k_2L + \big((k_1 - k_2)\,\alpha'^2 + k_2\big)\,M\}$$

If I is the moment of inertia of the bar and t is the time of a single vibration, we may write

$$\Theta = I\frac{\pi^2}{t^2}\psi.$$

If we hang up the bar so that $\alpha' = 0$ we have

$$k_2(L + M) = -\frac{\pi^2 I}{2alt^2}$$

and if we hang it up so that $\alpha' = \frac{1}{2}\pi$ we have again

$$k_2 L + k_1 M = -\frac{\pi^2 I'}{2alt'^2}$$

whence

$$k_2 = -\frac{\pi^2 I}{2alt_2} - \frac{1}{L + M}$$

$$k_1 = -\frac{1}{M}\left(\frac{\pi^2 I'}{2alt'^2} + k_2 L\right)$$

where

$$L = A^2_{,} - 3A_{,}A_{,,,}l^2 + (\tfrac{81}{20}A^2_{,,,} + \tfrac{15}{4}A_{,}A_{\rm v})\,l^4 - \tfrac{675}{56}A_{,,,}A_{\rm v}l^6 + \tfrac{1875}{192}A^2_{\rm v}\,l^8$$

$$M = -A^2_{,} + 6A_{,}A_{,,,}l^2 - (\tfrac{99}{20}A^2_{,,,} + \tfrac{45}{4}A_{,}A_{\rm v})l^4 + \tfrac{225}{14}A_{,,,}A_{\rm v}\,l^6 - \tfrac{725}{64}A^2_{\rm v}l^8$$

$$L + M = 3A_{,}\,A_{,,,}\,l^2 - (\tfrac{9}{10}\,A^2_{,,,} + \tfrac{15}{2}A_{,}\,A_{\rm v})\,l^4 + \tfrac{225}{56}A_{,,,}\,A_{\rm v}l^6 - \tfrac{75}{48}\,A^2_{\rm v}\,l^8$$

For a cleavage bar of calc spar we must use the general equation. For equilibrium we have

$$k_1\{A\alpha^2 + B\alpha'^2 - C\alpha\alpha'\} + k_2\{A\,(1 - \alpha^2) + B\,(1 - \alpha'^2) + C\alpha\alpha'\} = 0$$

which gives us the ratio of k_1 to k_2. For this experiment it is best to hang up the bar so that the axis is in the horizontal plane and we should then have

$$\alpha^2 = 1 - \alpha'^2$$

For obtaining another relation it is best to suspend the bar with $\alpha'=0$ and we then have the position of stable equilibrium at the point $\theta=\frac{1}{2}\pi$, which gives

$$\Theta = -2al\psi\{L[(k_1-k_2)\alpha^2+k_2]+Mk_2\} = \frac{\pi^2 I}{t^2}\psi,$$

whence

$$k_1 = -\frac{\pi^2 I}{2alt^2}\frac{1}{L\left[\left(1-\frac{k_2}{k_1}\right)\alpha^2+\frac{k_2}{k_1}\right]+M\frac{k_2}{k_1}}$$

these various equations give the complete solution of the problem of finding the various coefficients of magnetization.

PART II.—By WILLIAM W. JACQUES, Fellow in Physics of the Johns Hopkins University.

In the foregoing part of this paper there have been deduced mathematical expressions for the constants k and k' both for bismuth and for calc-spar crystals. In these expressions it is necessary to substitute certain quantities obtained by a series of experiments, and it is the purpose of the remaining portion of the paper to describe briefly the way in which these quantities were obtained.

These experiments are naturally divided into two parts. First, the exploration of the small magnetic field between the two poles of the electromagnet, and second, the determination of the time of swing and certain other constants relating to little bars of the substances experimented upon when suspended in this field.

In order to insure the constancy of the magnetic field, a galvanometer and variable resistance were inserted in the circuit through which the magnetizing current circulated. This space between the poles of the electromagnet in which the experiments were performed was a little larger than a hen's egg.

The method of exploring this field was as follows: In the line joining the centers of the two poles was placed a little brass rod, along which a very small coil of fine wire was made to slide. To this rod were fixed two little set-screws to regulate the distance through which the coil could be moved. Starting now always from the center, the coil was moved successively through distances a, b and c, and the corresponding deflections of a delicate mirror galvanometer contained in the circuit were noted. To each of these deflections was added the deflection due to quickly pulling the coil away from the center to a distance such that the magnetic potential was negligably small. Of course, experiments were made on both sides of the center of the field in order to eliminate any want of symmetry, and the distances through which the coil moved were all carefully measured with a dividing engine.

In order to reduce the deflections of the galvanometer to absolute measure, an earth inductor was included in the circuit with the little coil and galvanometer and the deflections produced by this were compared with those produced by moving the little coil. These deflections were taken between every two observations with the little coil.

The deflections due to moving the little coil, those due to the earth inductor and that due to pulling the coil away from the center are given in the following table:

	Distance *a.*	Distance *b.*	Distance *c.*
Coil	$4·407^{cm}$	$9·655^{cm}$	$6·363^{cm}$
Earth inductor	$33·138^{cm}$	$33·137^{cm}$	$33·162^{cm}$
Drawing coil away from center			$57·416^{cm}$

In order to determine the proper quantities for substitution in the expression for the magnetic potential of the field, it was necessary to measure, besides the deflections due to the little coil when moved through various distances and those due to the earth inductor.

The mean radius of the small coil = $·3912^{cm}$
Number of turns = 83·
Width of coil = $·1824^{cm}$
Depth of coil = $·1212^{cm}$
Integral area of earth inductor = $20716·2^{cm}$
Horizontal intensity of earth's magnetism = $·1984^{cgs}$

The quotient of the mean radius of the coil by the distance moved gave tan θ.

The linear measurements were made with a dividing engine.

The horizontal intensity of the earth's magnetism was determined by measuring the time of swing of a bar magnet and its effect upon a smaller galvanometer needle. The proper substitution of these quantities in the formula given gave the expression in absolute measure for the magnetic potential at any part of the field.

The remaining part of the experiment and the part that was attended with greatest difficulty, was to prepare little bars of the substances and to determine the times of vibration of these when suspended, first with the axis vertical and then with it horizontal in the magnetic field. Besides this, the dimensions and the moment of inertia of each bar had to be determined, and, in the case of the calc-spar, the angle the bar made with the equatorial line of the poles when in its position of equilibrium, had to be measured.

Bismuth and calc-spar were the two crystals experimented upon; quite a number of other substances were tried but failed to give good results because of the iron contained in them as an impurity. The bars were each about 15^{mm} long and about 2^{mm} in cross section. The force to be measured being only about ·00000001 of that exerted in the case of iron it was necessary to carry out the experiments with the very greatest care.

In order to obtain bars free from iron, very fine crystals of chemically pure substances were selected and the bars cleaved from them. They were then polished with their various sides parallel to the cleavage planes by rubbing on clean plates of steatite with oil. In order to remove any particles of iron that might have collected upon them during these processes, they were carefully washed with boiling hydrochloric acid and with distilled water and then wrapped in clean papers, and never touched except after washing the hands with hydrochloric acid and distilled water.

In order to reduce to a minimum the causes that might interfere with the accurate determination of the times of vibration of these bars the poles of the magnet were encased by a box of glass. From the top of this a tube four feet long extended up toward the ceiling, and inside this was hung a single fiber of silk so small as to be barely visible to the naked eye. The bars were placed in little slings of coarser silk fiber and suspended by this. Outside the glass case was a microscope placed horizontally and having a focus of about six inches. This was directed toward the suspended bar, and when the latter was at rest the cross hairs of the microscope fell upon a little scratch in one end of the bar. Near by was a telegraph sounder arranged to tick seconds. The bar was set swinging through a small arc by making and breaking the current, and the interval between two successive transits of the little scratch on the bar by the cross hairs of the microscope was measured in seconds and tenths of a second by the ear. By keeping count through a large number of successive transits the time of a single swing could be determined with very great accuracy. The bar was caused to swing only through a few degrees of arc and such small correction for amplitude as was found necessary was applied. The time of swing was determined first with the axis vertical and then with it horizontal. But besides the time of swing of each bar it was necessary to measure: the length; area of section; moment of inertia in each position; and for the calc-spar bar the angle it made with the equatorial plane of the magnet when in its position of equilibrium. This was not necessary in the case of bismuth, because its position of equilibrium lay in the equatorial plane.

Bismuth.

	Time of swing.	Moment of inertia.	Half length.	Area of section.
Axis, vertical.....	$7{\cdot}18^{sec}$	$\cdot10976^{cgs}$	$\cdot7709^{cm}$	$\cdot03778^{cm}$
Axis, horizontal, ..	$5{\cdot}76^{cec}$	$\cdot10943^{cgs}$		

Calc-Spar.

	Time of swing.	Moment of inertia.	Half length.	Area of section.	∝
Axis, vertical	$46{\cdot}35^{sec}$	$\cdot0303^{cgs}$	$\cdot8015^{cm}$	$\cdot0300^{cm}$	50° 30′
Axis, horizontal ...	$43{\cdot}39^{sec}$	$\cdot0300^{cgs}$			

The linear measurements were made with a dividing engine, the moments of inertia were calculated from the dimensions of the bars. The angle at which the calc-spar stood was measured by projecting the linear axis on a scale placed at a distance.

The above quantities being all determined and properly substituted, the solution of the equations gave for

Bismuth .... $k_{\prime} = -\cdot000\,000\,012\,554$
$k_{\prime\prime} = -\cdot000\,000\,014\,324$
Calc-spar..................... $k_{\prime} = -\cdot000\,000\,037\,930$
$k_{\prime\prime} = -\cdot000\,000\,040\,330$

ART. XLIII.—*On the Vapor-Densities of Peroxide of Nitrogen, Formic Acid, Acetic Acid, and Perchloride of Phosphorus;* by J. WILLARD GIBBS.

[Continued from page 293.]

Acetic acid.—For this substance the densities have been calculated by the formula

$$\log\frac{2{\cdot}073\,(D-2{\cdot}073)}{(4{\cdot}146-D)^2}=\frac{3520}{t_C+273}+\log p-11{\cdot}349, \qquad (12)$$

the constants 3520 and 11·349 being derived from the determinations of Cahours and Bineau, which with those of Horstmann and Troost are given in Table IV. The experiments of Cahours and Horstmann were made under atmospheric pressure, those of Horstmann* by the method of Bunsen, those of Cahours presumably by the method of Dumas. The numbers in the first column of the densities observed by Cahours are taken from the twentieth volume (1845) of the Comptes Rendus, except a few cases, distinguished by parentheses, which are taken from the preceding volume (1844). The numbers in the second column are taken from his Leçons de chimie générale élémentaire, 1856. These numbers seem to be based in part

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* Lieb. Ann., Suppl. VI, p. 65.

TABLE IV.—ACETIC ACID.

Experiments of CAHOURS,—HORSTMANN,—BINEAU,—TROOST.

Temperature.	Pressure.	Density calc. by eq. (12).	Density observed.			Excess of observed density.		
			Cahours.		Horstmann.	Cahours.		Horstmann.
			C. R.	Leçons.		C. R.	Leçons.	
338	(760)	2·077	2·08			·00		
336	(760)	2·077		2·082			+ ·005	
327	(760)	2·078	2·08	2·085		·00	+ ·007	
321	(760)	2·079	2·08	2·083		·00	+ ·004	
308	(760)	2·081		2·085			+ ·004	
300	(760)	2·082	2·08			·00		
295	(760)	2·084		2·083			— ·001	
280	(760)	2·089	2·08			— ·01		
272	(760)	2·093		2·088			— ·005	
254·6	747·2	2·105			2·135			+ ·030
252	(760)	2·108		2·090			— ·018	
250	(760)	2·111	2·08			— ·03		
240	(760)	2·122		2·090			— ·032	
233·5	752·8	2·132			2·195			+ ·063
231	(760)	2·137	(2 12)	2·101		(— ·02)	— ·036	
230	(760)	2·139	2·09			— ·05		
219	(760)	2·165	2·17	2 132		+ ·01	— ·033	
200	(760)	2·239	2·22	2·248		— ·02	+ ·009	
190	(760)	2·298	2·30	2·378		·00	+ ·080	
181·7	749·7	2·359			2·419			+ ·060
180	(760)	2·376		2·438			+ ·062	
171	(760)	2·466	2·42			— ·05		
170	(760)	2·477		2·480			+ ·003	
165·0	754·1	2·534			2·647			+ ·113
162	(760)	2·575		2·583			+ ·008	
160·3	751·6	2·594			2·649			+ ·055
160	(760)	2·601	2·48			— ·12		
152	(760)	2·716	(2·72)	2·727		(·00)	+ ·011	
150	(760)	2·747	2·75			·00		
145	(760)	2·826	(2·75)			(— ·08)		
140	(760)	2·910	2·90	2·907		— ·01	— ·003	
134·3	748·8	3·001			3·108			+ ·107
131·3	754·1	3·055			3·070			+ ·015
130	(760)	3·082	3·12	3·105		+ ·04	+ ·023	
128·6	752·9	3·103			3·079			— ·024
125	(760)	3·168	3·20			+ ·03		
124	(760)	3·185		3·194			+ ·009	
			Bineau.		Troost.	Bineau.		Troost.
132	757	3·05	(2·86)			(— ·19)		
130	59·7	2·31			2·12			— ·19
130	30·6	2·21			2·10			— ·11
129	633	3·03	(2·88)			(— ·15)		
36·5	11·32	3·63	3·62			— ·01		
35·0	11·19	3·65	3·64			— ·01		
30·0	6·03	3·61	3·60			— ·01		
28·0	10·03	3·75	3·75			·00		
24·0	5·75	3·71	3·70			— ·01		
22·0	8·64	3·82	3·85			+ ·03		
22	2·70	3·59	3·56			— ·03		
21·0	4·06	3·70	3·72			+ ·02		
20·5	10·03	3·86	3·95			+ ·09		
20·0	8·55	3·84	3·88			+ ·04		
20·0	5·56	3·77	3·77			·00		
19·0	4·00	3·73	3·75			+ ·02		
19	2·60	3·65	3·66			+ ·01		
12·0	5·23	3·88	3·92			+ ·04		
12	2·44	3·77	3·80			+ ·03		
11·5	3·76	3·84	3·88			+ ·04		

upon new experiments and in part upon a revision of the observations recorded in the Comptes Rendus, the calculations being carried out to another figure of decimals. They are therefore entitled to a greater weight than the numbers of the preceding column.

The agreement of the formula with the numbers given in the Leçons de chimie is very good, the greatest divergences being ·080 at 190° and ·062 at 180°. But at 190° the table in the Comptes Rendus agrees precisely with the formula, and at 171° (the next experiment) it shows a divergence in the opposite direction. The next divergences in the order of magnitude are $-{\cdot}033$, $-{\cdot}036$, $-{\cdot}032$ at 219°, 231°, 240°, respectively. Here the table in the Comptes Rendus agrees substantially with that of the Leçons, but the experiments of Horstmann show a divergence to the opposite direction. In fact, the three columns of observed densities nowhere agree in the direction of their divergence from the formula.

The somewhat decided differences between the results of Horstmann and those of Cahours may be due in part to the different methods of observation, especially to the entirely different manner of applying the heat and measuring the temperature. But the higher values obtained by Horstmann cannot be accounted for by too short an exposure to the source of heat, for his experiments were made with decreasing temperatures.

The determination of Bineau are taken from the same sources as those on formic acid, the earlier determinations being distinguished as before by parentheses. One of these (at 132°) was made by the method of Dumas, the other by that of Gay-Lussac. The smallness of the observed densities appears due to the presence of water. (An acidimetric test gave 295 parts of acid in 306.) The other experiments were made with the same apparatus which was used with formic acid and show even greater regularity in their results than the experiments with that substance. Only in one case is the influence of proximity to saturation seen, viz., at 20·5° and $10{\cdot}03^{mm}$, the pressure of saturated vapor at this temperature being about $12{\cdot}7^{mm}$.* In the remaining fifteen observations of this series, notwithstanding the very low pressures employed (from 2·44 to 11·32), the greatest difference between the observations and the formula is ·04, and the average difference ·02.

The two observations by Troost† were made by the method of Dumas, but at pressures very low for this method. The results obtained differ considerably from the formula, but not so much as in the case of his experiments at low pressure with peroxide of nitrogen.

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* This number is obtained from data given by Bineau by the same kind of interpolation which was used for formic acid.

† Comptes Rendus, vol. lxxxvi (1878), p. 1395.

Table V contains the experiments of Naumann* on acetic acid. These consist of ten series (distinguished by the letters A, B, C, etc.) of observations by Hoffmann's method.† The temperatures of the observations in the different series are for

TABLE V.—ACETIC ACID.

Experiments of NAUMANN.

		TEMPERATURE.								
		78°	100°	110°	120°	130°	140°	150°	160°	185°
A	Pressure.		393·5	411	432	455	477	498·5		565
	D. calc.		3·39	3·23	3·06	2·90	2·75	2·61		2·28
	D. obs.		3·44	3·31	3·14	2·97	2·82	2·68		2·36
	Exc. of D. obs.		+·05	+·08	+·08	+·07	+·07	+·07		+·08
B	Pressure.		342·3	359·3	377·5	398·5	417·5	436·5		495
	D. calc.		3·35	3·18	3·02	2·85	2·70	2·57		2·26
	D. obs.		3·37	3·22	3·06	2·89	2·75	2·63		2·31
	Exc. of D. obs.		+·02	+·04	+·04	+·04	+·05	+·06		+·05
C	Pressure.		258							382
	D. calc.		3·26							2·22
	D. obs.		3·17							2·25
	Exc. of D. obs.		—·09							+ 03
D	Pressure.		232		252	274	287·5	300		335
	D. calc.		3·23		2·87	2·72	2·58	2·46		2·21
	D. obs.		3·12		2·94	2·68	2·54	2·44		2·23
	Exc. of D. obs.		—·11		+·07	—·04	—·04	—·02		+·02
E	Pressure.	164	186	197	209	221	232	243	253	269
	D. calc.	3·53	3·15	2·97	2·81	2·65	2·52	2·41	2·32	2·18
	D. obs.	3·41	3·06	2·91	2·75	2·61	2·50	2·40	2·31	2·22
	Exc. of D. obs.	—·12	—·09	—·06	—·06	—·04	—·02	—·01	—·01	+·04
F	Pressure.	149	168			201				
	D. calc.	3·50	3·12			2·62				
	D. obs.	3·34	3·01			2·56				
	Exc. of D. obs.	—·16	—·11			—·06				
G	Pressure.	137	156	166·5	180	188	199	208·2		230
	D. calc.	3·48	3·09	2·92	2·75	2·60	2·47	2·37		2·17
	D. obs.	3·26	2·98	2·81	2·61	2·50	2·40	2·29		2·14
	Exc. of D. obs.	—·22	—·11	—·11	—·14	—·10	—·07	—·08		—·03
H	Pressure.	113	130	138·5	149	157·5	168·2	175		191·5
	D. calc.	3·42	3·03	2·85	2·69	2·55	2·43	2·33		2·15
	D. obs.	3·25	2·94	2·78	2·60	2·47	2·32	2·26		2·13
	Exc. of D. obs.	—·17	—·09	—·07	—·09	—·08	—·11	—·07		—·02
J	Pressure.	80	92	98·5	106	112·5	117·3		129·2	
	D. calc.	3·32	2·91	2·73	2·58	2·45	2·35		2·21	
	D. obs.	3·06	2·76	2·61	2·46	2·34	2·27		2·11	
	Exc. of D. obs.	—·26	—·15	—·12	—·12	—·11	—·08		—·10	
K	Pressure.	66	77·7	84	89·5	93	98	103		110·5
	D. calc.	3·26	2·85	2·68	2·53	2·40	2·31	2·24		2·12
	D. obs.	3·04	2·66	2·49	2·37	2·32	2·24	2·16		2·11
	Exc. of D. obs.	—·22	—·19	—·19	—·16	—·08	—·07	—·08		—·01

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* Lieb. Ann., vol. clv, S. 325.

† This is a modification of the method of Gay-Lussac, in which the heat is supplied by a vapor bath.

the most part the same, so that for each temperature we have observations through a wide range of pressures. Within each compartment of the table are given in order the pressure of an experiment, the density calculated by equation (12), the observed density, and the excess of observed density, the temperature of the experiment being given at the head of the column. These experiments, taken by themselves, seem to show an effect of pressure upon the density about one third greater than is indicated by the formula. But the divergences (of which the greatest is ·26 and the average ·085), are not large in view of the fact that the experiments were undertaken rather with the desire of obtaining a great number of observations with moderate labor, than with the intention of attaining the greatest possible accuracy.

The quantity of acid diminishes somewhat regularly from ·2084 grams in series A to ·0185 in series K. The volume, which was 154^{cc} in the experiment at 185° in series A, diminishes in the successive series, and in the same series with diminishing temperature, to 69·6^{cc} in the experiment at 78° in series K. It is worthy of notice that the greatest deviations from the formula occur where the liability to error is most serious with respect to pressure (which was measured without a cathetometer), to volume, and to the quantity of acid.

Far more serious than the absolute amount of these divergences, is the regularity which they exhibit. But it must be remembered that the observations are by no means entirely independent, and many sources of possible error, such as the calibration of the tube and the determination of the quantity of acid, might affect the results with considerable regularity.

Only to a slight degree can the divergences from the formula be accounted for by an insufficient exposure to the temperature of the experiment. The observations, except those at 78°, were made with increasing temperatures, and the greatest divergences from the formula are not in the positive direction. Yet the positive divergences occur where we should most expect to find them, if they were due to this cause, viz., in the series in which the greatest quantities of acid were used, and in cases in which the temperature seems to have been raised at once an unusual number of degrees. (See especially the observation at 120° in series D, and in general the observations at 185°, which exhibit if not a positive at least a diminution of negative excess.) In the observations at 78°, which were the last of each series, and therefore followed a fall of temperature from 185°, we find in some cases, especially in series G, H, and J, a negative divergence much greater than in the other determinations of the same series, and which appears to be referable to this circumstance.

In Table VI are exhibited the results of experiments by Playfair and Wanklyn,* in which the vapor of the acid was diluted with hydrogen or, in a single case (the experiment at 95·5°), by air. Columns I and II of the observed densities relate each to a series of observations by the method of Gay-Lussac, column III contains four independent determinations by the method of Dumas. The numbers in the column of pressures are, as in other similar cases, the partial pressures obtained by subtracting from the total pressure (which was never very much less than that of the atmosphere) that which would be exerted by the hydrogen or air alone.

TABLE VI.—ACETIC ACID.

Experiments of PLAYFAIR and WANKLYN.

Temperature.	Pressure.	Density calc. by eq. (12).	Density observed.			Excess of observed density.		
			I.	II.	III.	I.	II.	III.
212·5	322·8	2·124		2·060			—·064	
194	326·0	2·168		2·055			—·113	
186	254·4	2·173	1·936			—·237		
182	319·4	2·213		2·108			—·105	
166·5	289·5	2·293		2·350			+·057	
163	245·8	2·290	2·017			—·273		
132	227·5	2·628	2·292			—·336		
130·5	285·7	2·729		2·426			—·303	
119	269·0	2·914		2·623			—·291	
116·5	211·3	2·876	2·371			—·505		
95·5	(123·8)	3·105			2·594			—·511
86·5	(200·4)	3·432			3·172			—·260
79·9	(83·3)	3·297			3·340			+·043
62·5	(46·2)	3·473			3·950			+·477

The first observation of the first series gives the density 1·936, which is doubtless too small, since it is much less than the theoretical limit 2·073. Since the greater part of the measurements from which this number was calculated, were also used in reducing the other observations of the series, the error probably affects the other observations, and in a somewhat increased degree. This will account only for a part of the difference between the observations and the formula. The remaining part of the differences in this series, and the somewhat smaller differences in the next, may be due to the fact that the experiments of both series were conducted with descending temperatures. Yet the experiments of the third column, which were made by Dumas' method, do not exhibit any preponderance of positive values for the excess of observed density, but rather the opposite.

On the whole, these experiments furnish no decisive indication of any influence of the hydrogen or air upon the vapor.

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* Trans. Roy. Soc. Edinb., vol. xxii, p. 455.

They may be thought to corroborate slightly the tendency observed in the experiments of Naumann and Troost toward lower densities than the formula gives at very low pressures. Yet where the experiments of Naumann show the greatest deficiency in observed density (at 78° and 80^{mm}), an experiment of Playfair and Wanklyn, at almost precisely the same temperature and pressure, gives a trifling excess of observed density, and at a little lower temperature and pressure, where we should expect from the experiments of Naumann that the deficiency would be still greater, an experiment of Playfair and Wanklyn shows a great excess of density.

By combining the experiments of Cahours, Naumann and Troost, we may obtain observations of density at 130° for a very wide range of pressures. For one atmosphere, we may regard the formula as coinciding with the average of the numbers given by Cahours. For pressures between three-quarters and one-half of an atmosphere the experiments of Naumann show an excess of density; at pressures below half an atmosphere the experiments both of Naumann and of Troost show a deficiency of density as compared with the formula. For an indefinite diminution of pressure, there can be little doubt that the real density, like the value given by the formula, approaches the theoretical value 2·073. The greatest excess in the numbers obtained by experiment is ·07; the greatest deficiency is ·19, which occurs at $59{\cdot}7^{mm}$; the next in order of magnitude is ·11, which occurs more than once. These discrepancies are certainly such as may be accounted for by errors of observation. They do not appear to be greater than we might expect on the hypothesis of the entire correctness of the formula. On the other hand, the agreement is greater than we should expect, if we reject the theory on which the formula was obtained. It is about such as we might expect in a suitable formula of interpolation with three constants, which have been determined by the values of the density for one atmosphere, for half an atmosphere, and for infinitesimal pressures. But we must regard the actual formula, in its application to this single temperature, as having only two constants, of which one is determined so as to make the formula give the theoretical value for infinitesimal pressures, and the other so as to make it agree with the experiments of Cahours at the pressure of one atmosphere.

An entirely different method has been employed by Horstmann* to determine the vapor-density of this substance. A current of dried air is forced through the liquid acid, which is heated to promote evaporation, and the mixture of air and vapor is cooled to any desired temperature, with deposition of the excess of acid, by passing upward through a spiral tube in a suitable bath. The acid is then separated from the air, and the quantity of each determined. It is assumed that the air is exactly saturated with vapor on leaving the coil, and that it has the temperature of the bath. If we know the pressure of saturated vapor for that temperature, and assume the validity of Dalton's law, it is easy to calculate the density of the vapor. For the pressure of the air is found by subtracting the pressure of the vapor from the total pressure, (the experiments were so conducted that this was the same as the actual pressure of the atmosphere,) and the ratio of the weights of the acid and the air obtained by analysis, divided by the ratio of their pressures, will give the ratio of their densities. The pressures of saturated vapor employed by Horstmann are those given by Landolt,* and differ greatly from the determinations of Regnault, in some cases being nearly twice as great,—a difference noticed but not explained by Landolt, who however gives determinations (previously unpublished) of Wüllner, which somewhat exceed his own. (On the other hand, the observations of Bineau substantially agree with those of Regnault.)

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* Berichte der deutschen chemischen Gesellschaft, Jahrg. iii (1870), S. 78; and Jahrg. xi (1878), S. 1287.

If we compare the observations of Horstmann with the values given by equation (12), on the basis of Landolt's pressures, we find a very marked disagreement, as may be seen by the following numbers, which relate to the highest temperatures of Horstmann's experiments, where the disagreement is least.

Temperature	63·1	62·9	59·9	51·1	49·0	48·7	44·6	41·4
Pressure (Land.)	110·0	109·2	97·0	69·0	63·4	63·0	53·1	46·6
Density calc. eq. (12)	3·67	3·67	3·69	3·75	3·77	3·77	3·79	3·81
Density obs.	3·19	3·11	3·12	3·16	2·89	2·98	2·75	2·62

It will be observed that while the values obtained from equation (12) increase with diminishing temperatures, the values obtained from Horstmann's experiments diminish. This diminution continues as far as the experiments go, until finally at 12° or 15° the densities are only one half as great as those obtained by Bineau, by direct experiment at the same temperatures and at somewhat less pressures, in a series of observations which bear every mark of a very exceptional precision. (Compare Tables VII and IV.) The explanation of this disagreement is doubtless to be found in the values of the pressures employed in the calculations, and it will be interesting to see how the results may be modified by the adoption of different pressures.

In determinations of the pressure of saturated vapors, too great values are so much more easily accounted for than errors in the opposite direction, especially when the pressures are small, that especial interest attaches to the lowest figures which are supported by a competent authority. The experiments of Regnault* were made with three different preparations of acetic acid, of which the second was once, and the third twice, purified by distillation over anhydrous phosphoric acid. Each distillation considerably diminished the pressure of the saturated vapor, the effect of the second distillation being about half that of the first. The numbers obtained with the third preparation are given in the following table with their logarithms, and the differences of the logarithms for one degree of temperature.

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* Lieb. Ann., Suppl. vi (1868), p. 157.

Temperature.	Pressure.	log. pressure.	diff. per 1°.
9·71	6·42	·8075	·0239
12·12	7·33	.8651	·0272
14·33	8·42	·9253	·0161
14·87	8·59	·9340	·0252
17·23	9·85	·9934	·0251
19·84	11·455	1·0590	·0237
22·37	13·15	1·1189	·0232
25·28	15·36	1·1864	

The uniformity of the numbers in the last column shows the remarkable precision of the determinations. At the same time it is evident that the differences in these numbers are due principally to the errors of observation, so that numbers obtained by interpolation between the logarithms of the observed pressures will be somewhat better (on account of averaging of the errors) than the original determinations.

The values obtained by such an interpolation have been used for the comparison of Horstmann's experiments with the formula (12) which is given in table VII. Unfortunately this comparison cannot be extended above 25°, which is the limit of Regnault's experiments. The first three columns of the table give the temperatures of Horstmann's experiments, the pressures corresponding to these temperatures according to the determinations of Landolt, and the density deduced from Horstmann's experiments by the use of these pressures. To these columns, which are taken from Horstmann's paper, are added the pressure derived from Regnault's observations by the logarithmic interpolation described above, the density calculated by equation (12) from these pressures and the temperatures of the first column, and the densities obtained by combining Horstmann's experiments with Regnault's pressures. This column is derived from the second, third and fourth, as follows. If w and W denote respectively the weights of vapor and of air which pass through the apparatus in the same time, P the height of the barometer, and p_L the pressure of saturated vapor as determined by Landolt, the densities obtained on the basis of Landolt's pressures, and given in the third column, are evidently represented by $\frac{w(\mathrm{P}-p_{\mathrm{L}})}{\mathrm{W}p_{\mathrm{L}}}$. The numbers of the fifth column, which are represented in the same way by $\frac{w(\mathrm{P}-p_{\mathrm{R}})}{\mathrm{W}p_{\mathrm{R}}}$, where p_{R} denotes the pressure as determined by Regnault's experiments, have been calculated by the present writer by multiplying the numbers of the third column by $\frac{p_{\mathrm{L}}(\mathrm{P}-p_{\mathrm{R}})}{p_{\mathrm{R}}(\mathrm{P}-p_{\mathrm{L}})}$.

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* Mém. Acad. Sciences, vol. xxvi, p. 758. The experiments date from 1844.

TABLE VII.—ACETIC ACID.

Determinations of Vapor-density by Distillation.

Temperature.	Pressure acc. to Landolt.	Density observed, Horstmann and Landolt.	Pressure acc. to Regnault.	Density calc. from Regnault's pressures by eq. (12).	Density observed, Horstmann & Regnault.	Excess of observed density.	
						I.	II.
25·0	23·5	2·42	15·13	3·86	3·80	—·06	
23·8	22·4	2·23	14·19	3·86	3·56		—·30
22·6	21·6	2·29	13·31	3·87	3·76	—·11	
21·5	20·4	2·24	12·54	3·87	3·68	—·19	
20·4	19·2	2·05	11·81	3·88	3·37		—·51
20·2	19·0	2·28	11·68	3·88	3·75	—·13	
20·0	18·9	2·13	11·56	3·88	3·52		—·36
17·4	16·8	2·09	9·95	3·89	3·56	—·33	
15·6	15·6	1·98	8·96	3·90	3·48	—·42	
15·3	15·3	1·95	8·81	3·90	3·42		—·48
15·3	15·3	1·85	8·81	3·90	3·24		—·66
14·7	15·1	1·78	8·54	3·91	3·18	—·73	
12·7	13·7	1·96	7·60	3·91	3·56	—·35	
12·4	13·5	1·89	7·46	3·92	3·45	—·47	

As the height of the barometer in Horstmann's experiments is not given, it has been necessary to assume P=760. The inaccuracy due to this circumstance is evidently trifling. The last two columns of the table, which relate to different series of experiments by Horstmann (a distinction not observed in other parts of the table), give the excess of the densities thus obtained from Horstmann's and Regnault's experiments above the values calculated from equation (12) with the use of Regnault's determinations of pressure.

The densities obtained by experiment are without exception less than those obtained from equation (12). At the highest temperatures, where the liability to error is the least, both in respect to the measurement of the pressure of saturated vapor and in respect to the analysis of the product of distillation, the results of experiment are most uniform, and most nearly approach the numbers required by the formula. At the lowest temperatures, the greatest observed density is about one-eleventh less than that required by the formula, the difference being about the same as between the highest and lowest observed values for the same temperature.

Since each successive purification of the substance employed by Regnault diminished the pressure of its vapor, it is not improbable that the pressures might have been still farther diminished by farther purification of the substance. The pressures which we have used are therefore liable to the suspicion of being too high, and it is quite possible that more accurate values of the pressure would still farther reduce the deficiency of observed density.

Perchloride of phosphorus.—For this substance, we have at atmospheric pressure a single determination of vapor-density by Mitscherlich,* and a series of determinations by Cahours;† at lower pressures we have determinations by Wurtz‡ and by Troost and Hautefeuille.§ In the experiments of Wurtz the

TABLE VIII.—PERCHLORIDE OF PHOSPHORUS.

Experiments of MITSCHERLICH, CAHOURS, WURTZ, and TROOST and HAUTEFEUILLE.

Temperature.	Pressure.	Density calc. by eq. (18).	Density observed.		Excess of observed density.	
			Mitsch.	Cahours.	Mitsch.	Cahours.
336	(760)	3·610		3·656		+·046
327	754	3·614		3·656		+·042
300	765	3·637		3·654		+·017
289	(760)	3·656		3·69		+·034
288	763	3·659		3·67		+·011
274	755	3·701		3·84		+·139
250	751	3·862		3·991		+·129
230	746	4·159		4·302		+·142
222	753	4·344	4·85		+·506	
208	(760)	4·752		4·73		—·021
200	758	5·018		4·851		—·167
190	758	5·368		4·987		—·381
182	757	5·646		5·078		—·568
			Wurtz.	T. & H.	Wurtz.	T. & H.
178·5	227·2	5·053		5·150		+·097
175·8	253·7	5·223		5·235		+·012
167·6	221·8	5·456		5·415		—·041
154·7	221	5·926		5·619		—·307
150·1	225	6·086		5·886		—·200
148·6	244	6·169		5·964		—·205
145	391	6·45	6·55		+·10	
145	311	6·37	6·70		+·33	
145	307	6·36	6·33		—·03	
144·7	247	6·287		6·14		—·147
137	281	6·53	6·48		—·05	
137	269	6·51	6·54		+·03	
137	243	6·48	6.46		—·02	
137	234	6·47	6·42		—·05	
137	148	6·31	6·47		+·16	
129	191	6·59	6·18		—·41	
129	170	6·56	6·63		+·07	
129	165	6·55	6·31		—·24	

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* Pogg. Ann., vol. xxix (1833), p. 221.

† Comptes Rendus, vol. xxi (1845), p. 625; and Annales de Chimie et de Physique, Ser. 3, vol. xx (1847), p. 369.

‡ Comptes Rendus, vol. lxxvi (1873), p. 601. § Ibid., vol. lxxxiii (1876), p. 977.

pressure was reduced by mixing the vapor with air. In Table VIII all these determinations are compared with the formula

$$\log\frac{3\cdot6\,(\mathrm{D}-3\cdot6)}{(7\cdot2-\mathrm{D})^2}=\frac{5441}{t_{\mathrm{C}}+273}+\log p-14\cdot353. \qquad (13)$$

The differences between the calculated and observed values are often large, in six cases exceeding ·30; but they exhibit in general that irregularity which is characteristic of errors of observation. We should expect large errors in the observed densities, on account of the difficulty of obtaining the substance in a state of purity, and because the large value of the density renders it very sensitive to the effect of impurities which diminish the density,—also because the specific heat of the vapor is great, as shown by the numerator of the fraction in the second member of (13),* and because the density varies very rapidly with the temperature as seen by the numbers in the third column of Table VIII.

But at the two lowest temperatures of Cahours' experiments, the differences of the observed and calculated densities (·381 and ·568) are not only great, but exhibit, in connection with the adjacent numbers, a regularity which suggests a very different law from that of the formula. In fact, the densities obtained by Cahours at atmospheric pressure and those obtained by Troost and Hautefeuille at pressures a little less than one-third of an atmosphere seem to form a continuous series, notwithstanding the abrupt change of pressure. Yet it is difficult to admit that the density is independent of the pressure. So radical a difference between the behavior of this substance and that of the others which we have been considering requires unequivocal evidence. Now it is worthy of notice that the experiment at 182°, in which the greatest discrepancy is seen, is not given in the first record of the experiments, which was in the Comptes Rendus in 1845. It is given in the Annales de Chimie et de Physique in 1847, where it is called the first experiment. (The experiment at 336° is also omitted in the Comptes Rendus and that at 208° in the Annales,—otherwise the lists are the same.) If it was the first experiment in point of time, which is apparently the meaning, it was made before the publication in the Comptes Rendus, and we can only account for its omission by supposing that it was a preliminary experiment, in which its distinguished author did not feel sufficient confidence to include it at first with his other determinations, although he afterwards concluded to insert it. If we reject this observation as doubtful, the disagreement between the formula and observation, appears to be within the limits of possible error, but additional experiments will be necessary to confirm the formula.*

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* Compare Trans. Conn. Acad., vol. iii, p. 243, and pp. 286, 287 of this volume.

Experiments have also been made by M. Wurtz in which the vapor of the perchloride of phosphorus was diluted with that of the protochloride.† These experiments may be used to test equation (8), which, when the values of its constants are determined by equation (13), reduces to the form

$$\log \frac{p_5}{p_2 p_3} = \frac{5441}{t_c + 273} - 13{\cdot}751, \tag{14}$$

where p_5, p_2, and p_3 denote the partial pressures due respectively to the PCl_5, the Cl_2, and the PCl_3, existing as such in the gas-mixture. Since these quantities cannot be the subjects of immediate observation, a farther transformation of the equation will be convenient. Let M_3, M_2 denote the quantities of the protochloride and of chlorine of which the mixture may be formed, and P_3, P_2 the pressure which would belong to each of these if existing by itself with the same volume and temperature. These quantities will be connected by the equations

$$P_2 = \frac{kt\,M_2}{2{\cdot}22\,v}, \qquad P_3 = \frac{kt\,M_3}{4{\cdot}98\,v}, \tag{15}$$

where k denotes the same constant as on page 286. From the evident relations

$$P_2 = p_2 + p_5, \qquad P_3 = p_3 + p_5, \qquad p = p_2 + p_3 + p_5,$$

we obtain

$$p_5 = P_2 + P_3 - p, \qquad p_2 = p - P_3, \qquad p_3 = p - P_2;$$

and by substitution of these values in equation (14),

$$\log \frac{P_2 + P_3 - p}{(p - P_2)\,(p - P_3)} = \frac{5441}{t_c + 273} - 13{\cdot}751. \tag{16}$$

In view of the relations (15), this may be regarded as an equation between the pressure, the temperature, the volume, and the quantities of protochloride of phosphorus and chlorine into which the gas-mixture is resolvable.

It is in this form that we shall apply the equation to the experiments of M. Wurtz, the results of which are exhibited in Table IX. The first column gives the number distinguishing each experiment in the original memoir; the second, the temperature; the third the observed pressure (p) of the mixture of PCl_5, PCl_3, and Cl_2, which is the barometric pressure corrected for the small quantity of air remaining in the flask; the fourth, the pressure π due to the *possible perchloride*, found by subtracting the pressure due to the excess of protochloride (this pressure is calculated from the theoretical density of the protochloride) from the total pressure; the fifth, the density δ of the possible perchloride calculated from its pressure π with the temperature and volume. The numbers of these five columns are taken from the memoir cited, except that the correction of the barometric pressures has been applied by the present writer in accordance with the data furnished in that memoir. The two next columns contain the values of P_2 and P_3. These would naturally be calculated from M_2 and M_3 by equations (15). But since the values of M_2 and M_3 have not been given explicitly, those of P_2 and P_3 have been calculated from the recorded values of π and δ. Since the weight of the *possible perchloride* is $\frac{7{\cdot}2}{2{\cdot}22}$ M_2, we have

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* Additional experiments on the density of this vapor have been made by M. Cahours, concerning which he says in 1866: "Les déterminations qui je viens d'effectuer à 170 et 172 degrés (ce corps bout vers 160 à 165 degrés) m'ont donné des nombres qui, bien que notablement plus forts que ceux que j'ai obtenus antérieurement à 182 et 185 degrés, sont encore bien éloignés de celui que correspond à 4 volumes." Comptes Rendus, t. 63, p. 16. So far as the present writer has been able to ascertain, these determinations have not been published. The formula gives 6·025 for 170° and 5·973 for 172°, at atmospheric pressure. The number corresponding to four volumes is 7·20.

† Comptes Rendus, vol. lxxvi (1873), p. 601.

TABLE IX.—PERCHLORIDE AND PROTOCHLORIDE OF PHOSPHORUS.

Experiments on the mixed vapors by WURTZ.

No. of exp.	t_C	p (obs.)	π	δ	P_2	P_3	p calc. by eq. (16).	Excess of obs. value of p.
XII	173·29	756·1	423	6·68	392·4	725·5	760·7	−4·6
X	165·4	748·4	413	6·80	390·1	725·5	747·9	+ ·5
VII	176·24	751·0	411	6·88	392·7	732·7	773·1	−22·1
VIII	169·35	724·1	394	7·16	391·8	721·9	750·5	−26·4
V	175·26	743·3	343	7·03	334·9	735·2	764·4	−21·1
II	164·9	758·5	338	7·38	346·4	766·9	782·9	−24·4
XI	175·75	760·0	318	7·00	309·2	751·2	776·8	−16·8
IV	175·26	756·3	271	7·06	265·7	751·0	770·9	−14·6
IX	160·47	753·5	214	7·44	221·1	760·6	766·8	−13·3
I	165·4	760·0	194	7·25	195·3	761·3	768·5	− 8·5
VI	170·34	751·2	174	8·30	200·6	777·8	787·6	−36·4
III	174·28	742·7	168	7·74	180·6	755·3	766·5	−23·8

$$\delta = \frac{7{\cdot}2\, M_2\, k\, t}{2{\cdot}22\, v\, \pi} = \frac{7{\cdot}2}{\pi} P_2.$$

Moreover,

$$p - \pi = P_3 - P_2,$$

since both members of the equation express the pressure due to the excess of the protochloride. The values of P_2 and P_3 were obtained by these equations.

The eighth column of the table gives the values of p calculated from the preceding values of t_C, P_2, and P_3, by equation (16); and the last column, the difference of the observed and calculated values of p. The average difference is 18^{mm}, or a little more than two per cent, the observed pressure being almost uniformly less than the calculated value. This deficiency of pressure is doubtless to be accounted for by a fact which MM. Troost and Hautefeuille have noticed in this connection. The protochloride of phosphorus deviates quite appreciably from the laws of Mariotte, Gay-Lussac, and Avogadro, the product of the volume and pressure of a given quantity of vapor at 180° and the pressure of one atmosphere being 1·548 per cent less than at the same temperature and the pressure of one-half an atmosphere.* Now we may assume as a general rule that when the product of volume and pressure of a gas is slightly less than the theoretical number (calculated by the laws of Mariotte, Gay-Lussac, and Avogadro) the difference for any same temperature is nearly proportional to the pressure.† It is therefore probable that between 160° and 180°, at pressures of about one atmosphere, the product of volume and pressure for protochloride of phosphorus is somewhat more than three per cent less than the theoretical number. The experiments of Wurtz, as exhibited in Table IX, show that the pressure, and therefore the product of volume and pressure, (we may evidently give the volume any constant value as unity,) in a mixture consisting principally of the protochloride is on the average a little more than two per cent less than is demanded by theory, the differences being greater when the proportion of the protochloride is greater. The deviation from the calculated values is therefore in the same direction and about such in quantity as we should expect.‡

M. Wurtz has remarked that the average value of δ (the density of the *possible perchloride*) is nearly identical with the theoretical density of the perchloride, and appears inclined to attribute the variations from this value to the errors of experiment. Yet it appears very distinctly in Table IX, in which the experiments are arranged according to the value of π (the pressure due to the *possible perchloride*), that δ increases as π diminishes. The experiments of MM. Troost and Hautefeuille show that the coincidence remarked by M. Wurtz is due to the fact that on the average in these experiments the deficiency of the density of the possible perchloride (compared with the theoretical value) is counterbalanced by the excess of density of the protochloride. When $\pi > 400$, the effect of the deficiency in the density of the possible perchloride distinctly preponderates; when $\pi < 250$, the effect of the excess of density in the protochloride distinctly preponderates. But the magnitude of the differences concerned is not such as to invalidate the general conclusion established by the experiments of M. Wurtz, that the dissociation of the perchloride may be prevented (at least approximately) by mixing it with a large quantity of the protochloride.

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* Troost and Hautefeuille, Comptes Rendus, vol. lxxxiii (1876), p. 334.

† Andrews, "On the Gaseous State of Matter." Phil. Trans., vol. clxvi (1876), p. 447.

‡ The deviation of the protochloride of phosphorus from the laws of ideal gases shows the impossibility of any *very close* agreement between such equations as have been deduced in this paper and the results of experiment in the case of gas-mixtures in which this substance is one of the components. With respect to the question whether future experiments on the vapor of the perchloride (alone, or with an excess of chlorine or of the protochloride), will reduce the disagreement between the calculated and observed values to such magnitudes as occur in the case of the protochloride alone, it would be rash to attempt to anticipate the result of experiment.

Table for facilitating calculation.—The numerical solution of equations (10), (11), (12) and (13) for given values of t and p may be facilitated by the use of a table. If we set

$$\varDelta = \frac{\mathrm{D}}{\mathrm{D}_1}, \tag{17}$$

$$\mathrm{L} = \log \frac{1000\,\mathrm{D}_1\,(\mathrm{D} - \mathrm{D}_1)}{(2\mathrm{D}_1 - \mathrm{D})^2} = \log \frac{1000\,(\varDelta - 1)}{(2 - \varDelta)^2}, \tag{18}$$

we have for peroxide of nitrogen,

$$\mathrm{L} = \frac{3118{\cdot}6}{t_{\mathrm{C}} + 273} + \log p - 9{\cdot}451; \tag{19}$$

for formic acid,

$$\mathrm{L} = \frac{3800}{t_{\mathrm{C}} + 273} + \log p - 9{\cdot}641; \tag{20}$$

for acetic acid,

$$\mathrm{L} = \frac{3520}{t_{\mathrm{C}} + 273} + \log p - 8{\cdot}349; \tag{21}$$

and for perchloride of phosphorus,

$$\mathrm{L} = \frac{5441}{t_{\mathrm{C}} + 273} + \log p - 11{\cdot}353. \tag{22}$$

By these equations the values of L are easily calculated. The values of $\varDelta$ may then be obtained by inspection (with interpolation when necessary) of the following table. From $\varDelta$ the value of D may be obtained by multiplying by D_1, viz., by 1·589 for peroxide of nitrogen or formic acid, by 2·073 for acetic acid, and by 3·6 for perchloride of phosphorus.[*]

The constants of these equations are of course subject to correction by future experiments, which must also decide the more general question—in what cases, and within what limits,

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[*] The value of Δ diminished by unity expresses the ratio of the number of the molecules of the more complex type to the whole number of molecules. Thus, if $\Delta = 1{\cdot}20$, in the case of peroxide of nitrogen there are 20 molecules of the type N_2O_4 to 80 of the type NO_2, or in the case of perchloride of phosphorus there are 20 molecules of the type PCl_5 to 40 of the type PCl_3 and 40 of the type C_2. A consideration of the varying values of Δ is therefore more instructive than that of the values of D, and it would in some respects be better to make the comparison of theory and experiment with respect to the values of Δ.

TABLE X.

For the solution of the equation: $\log \frac{1000\,(\Delta - 1)}{(2 - \Delta)^2} = \text{L}.$

L	Δ	Diff.	L	Δ	Diff.	L	Δ	Diff.
·7	1·005	1	3·0	1·382	39	5·3	1·932	7
·8	1·006	2	3·1	1·421	40	5·4	1·939	6
·9	1·008	2	3·2	1·461	39	5·5	1·945	6
1·0	1·010	2	3·3	1·500	37	5·6	1·951	5
1·1	1·012	3	3·4	1·537	37	5·7	1·956	5
1·2	1·015	4	3·5	1·574	35	5·8	1·961	4
1·3	1·019	5	3·6	1·609	33	5·9	1·965	4
1·4	1·024	6	3·7	1·642	31	6·0	1·969	3
1·5	1·030	7	3·8	1·673	30	6·1	1·972	3
1·6	1·037	9	3·9	1·703	27	6·2	1·975	3
1·7	1·046	10	4·0	1·730	25	6·3	1·978	2
1·8	1·056	13	4·1	1·755	23	6·4	1·980	2
1·9	1·069	15	4·2	1·778	22	6·5	1·982	2
2·0	1·084	18	4·3	1·800	19	6·6	1·984	2
2·1	1·102	20	4·4	1·819	18	6·7	1·986	1
2·2	1·122	24	4·5	1·837	17	6·8	1·987	2
2·3	1·146	26	4·6	1·854	14	6·9	1·989	1
2·4	1·172	30	4·7	1·868	14	7·0	1·990	
2·5	1·202	32	4·8	1·882	12	7·2	1·992	
2·6	1·234	34	4·9	1·894	11	7·4	1·994	
2·7	1·268	37	5·0	1·905	10	7·6	1·995	
2·8	1·305	38	5·1	1·915	9	7·8	1·996	
2·9	1·343	39	5·2	1·924	8	8·0	1·997	
3·0	1·382		5·3	1·932		9·0	1·999	

and with what degree of approximation, the actual relations can be expressed by equations of such form. In the case of perchloride of phosphorus especially, the formula proposed requires confirmation.

ART. XLIV.—*On a secular inequality in the Moon's Motion produced by the oblateness of the Earth;* by J. N. STOCKWELL.

HAVING been engaged, during a number of years past, in a thorough and systematic examination of the physical theory of the moon's motion, it seems proper to make known to astronomers, in advance of the publication of my researches which are now essentially completed, one of the most curious and interesting results at which I have arrived relative to the motion of our satellite.

It has been known, since the time of Newton, that the attraction of a spheroidal body on a point without its surface is different from that of a sphere having the same mass. If the spheroid be one of revolution, like the earth, the attraction depends not only on the distance of the attracted point from the earth's center, but also on its distance from the equator. If the attracted point were situated in the plane of the earth's equator the attraction of the earth upon it would be greater at a given distance than if the earth were spherical. The attraction would also be greater either north or south of the equator until we reached the paralled of about 35° 16′, at which points the attraction of the earth would be nearly independent of its spheroidal form. For all points situated beyond the parallels of 35° 16′ the attraction of the earth is less than it would be if it were spherical.

From these general considerations we may draw the following conclusions: *First.* A body would revolve round the earth, at a given distance from its center, in less time if it moved in the plane of the equator, than it would if the earth were spherical; and its motion would be uniform. *Second.* The time of revolution would be increased if the body moved in a plane inclined to the equator, and its motion would not be uniform, on account of the redundancy or deficiency of matter beneath the different parts of its course. It is evident that the motion in an orbit perpendicular to the equator would suffer greater variations from the unequal distribution of matter, than it would for any other inclination.

We shall now apply the preceding considerations to the motion of the moon around the earth, supposing for greater simplicity that her orbit is circular.

Since the inclination of the moon's orbit to the equator is always less than 35° 16′, it follows that the earth's attraction on the moon is always greater than it would be if the earth were spherical. But since the inclination varies between the limits of about 18° 19′ and 28° 35′ during a period of about nineteen years, it follows that the earth's attraction undergoes sensible variations; and hence the moon's place at any given time requires to be corrected on account of the varying inclination of its orbit to the equator. The corrections to the moon's longitude and latitude arising from this cause have been calculated, and applied to the moon's place during the whole of the present century. All these varying inequalities in the forces would accurately compensate each other during each revolution of the moon's node, provided the mean inclination of the lunar orbit to the equator always retained the same value. Now the mean inclination of the moon's orbit to the equator is the same as the inclination of the ecliptic to the same plane; and since the inclination of the ecliptic to the equator is slowly becoming less, it follows that the plane of the moon's orbit is gradually approaching the plane of the equator; and hence its mean motion must be increasing. All these various conclusions are fully confirmed by mathematical analysis, and were first suggested by it.

Having thus shown the existence of a secular inequality in the moon's motion depending on the oblateness of the earth, it only remains to determine its amount. But as a mathematical analysis of the problem is not within the scope of the present paper, I shall be content with a mere statement of the semi-general formula together with its numerical value.

If we put ε_0 for the obliquity of the ecliptic in 1850, and ε for its value at any time t, and also suppose that the ellipticity of the earth is $\frac{1}{300}$, I find the following value for the secular inequality depending on the earth's oblateness, namely:

$$\delta v = +24''\cdot827 \int (\sin^2\varepsilon_0 - \sin^2\varepsilon)dt.$$

If we develop the integral into a series and retain only the first term we shall have

$$\int (\sin^2\varepsilon_0 - \sin^2\varepsilon)dt = +0\cdot008675\, i^2,$$

in which i denotes the number of centuries counting from 1850

Hence the secular inequality becomes

$$\delta v = 0''\cdot1981\, i^2.$$

This term, though small, is of sufficient importance to be used in computing ancient eclipses.

In conclusion I would state that I have found several inequalities in the moon's motion which are not recognized by existing theories, of even greater practical interest and importance than the one to which I have called attention in this paper.

Cleveland, Oct. 2, 1879.

ART. XLV.—*Discovery of two new Asteroids;* by Professor C. H. F. PETERS. Communication to the Editors dated Litchfield Observatory of Hamilton College, Clinton, N. Y., October 6, 1879.

TWO more planets of the asteroid group were found by me in the month of September, respectively on the 11th and 25th. I communicate the observations hitherto obtained.

(202) *Chryseïs.*

1879.	Ham. Coll. m. t.			App. Æ.			App. Decl.			No. of comp.
Sept. 11.	12^h	$\pm^m$	^{s}	23^h	51^m	$16^s\cdot$	$-8°$	$53'\cdot5$		[rough estimate.]
Sept. 21.	13	18	27	23	44	15·93	−9	58	4·4	10
Sept. 23.	12	7	56	23	42	53·47	−10	9	35·0	9
Sept. 26.	12	46	49	23	40	48·42	−10	26	55·2	10
Oct. 4.	8	56	13	23	35	39·12	−11	6	56·5	6

(203) *Pompeja.*

1879.	Ham. Coll. m. t.			App. Æ.			App. Decl.			No. of comp.
Sept. 25.	14^h	48^m	21^s	0^h	57^m	$6^s\cdot18$	$+8°$	15	30·4	12
Sept. 26.	13	41	15	0	56	19·53	+8	12	10·9	10
Oct. 4.	10	57	30	0	49	37·80	+7	41	41·8	14

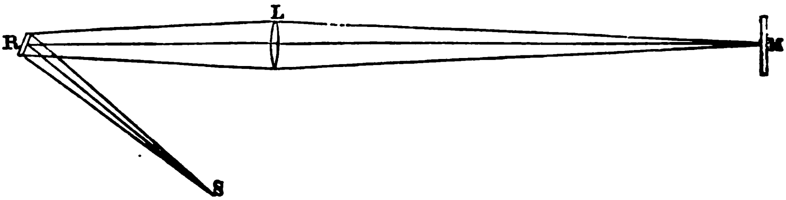
The magnitude of the first is now $11^m\cdot0$, that of the latter $10^m\cdot5$.

ART. XLVI. — *Experimental Determination of the Velocity of Light*; by ALBERT A. MICHELSON, Master, U. S. Navy.*

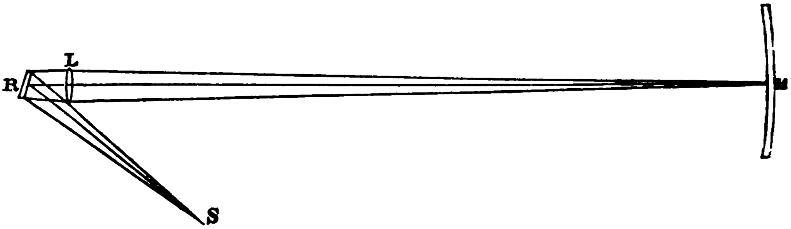
[Abstract of paper read before the American Association for the Advancement of Science.]

LET S, fig. 1, be a slit through which light passes, falling on R, a mirror free to rotate about an axis at right angles to the plane of the paper; L, a lens of great focal length, upon which the light falls, which is reflected from R. Let M be a plane mirror, whose surface is perpendicular to the line RM, passing through the centers of R, L and M, respectively. If L be so placed that an image of S is formed on the surface of M, then, this image acting as the object, its image will be formed at S, and will coincide point for point with S.

1.



2.



If, now, R be turned about the axis, so long as the light falls on the lens, an image of the slit will still be formed on the surface of the mirror, though on a different part, and as long as the returning light falls on the lens an image of this image will be formed at S, notwithstanding the change of position of the first image at M. This result, namely, the production of a stationary image of an image in motion, is absolutely essential. It was first accomplished by Foucault, and in a manner differing apparently but little from the foregoing.

In this case, L, fig. 2, served simply to form an image of S at M; and M, the returning mirror, was spherical, the center of curvature coinciding with the axis of R. The lens, L, was placed as near as possible to R. The light forming the return image lasts, in this case, while the first image is sweeping over the face of the mirror, M. Hence, the greater the distance, RM, the larger must be the mirror, in order that the same quantity of light may be preserved, and its dimensions would soon become inordinate. The difficulty was partly met by Foucault, by using five concave reflectors instead of one; but even then the greatest distance he found it practicable to use was only twenty meters.

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* Prepared for this place by the Author.

Returning to fig. 1, suppose that R is in the principal focus of the lens, L; then, if the plane mirror, M, have the same diameter as the lens, the first or moving image will remain upon M as long as the axis of the pencil of light remains on the lens, and *this will be true no matter what the distance may be.*

When the rotation of the mirror R becomes sufficiently rapid, then the flashes of light which produce the second or stationary image become blended, so that the image appears to be continuous. But now it no longer coincides with the slit, but is deflected in the direction of the rotation, and through twice the angular distance described by the mirror, during the time required for light to travel twice the distance between the mirrors. This displacement is measured by its arc, or rather, by its tangent. To make this as large as possible, the distance between the mirrors, the radius or distance from the revolving mirror to the slit, and the speed of rotation should be made as great as possible.

The second condition conflicts with the first, for the "radius" is the difference between the distances of the principal focus, and the conjugate focus (for the distant mirror). The greater the "distance," therefore, the smaller will be the "radius." There are two ways of solving the difficulty: first, by using a lens of great focal length, and, secondly, by placing the revolving mirror within the principal focus of the lens. Both means were employed. The focal length of the lens was 150 feet, and the mirror was placed fifteen feet within the principal focus. A limit is soon reached, however, for the quantity of light received diminishes very rapidly as the revolving mirror approaches the lens.

The chief objection urged in reference to the experiments made by Foucault is that the deflection was too small to be measured with the required degree of accuracy. This deflection was but a fraction of a millimeter, and when it is added that the image is always more or less indistinct on account of atmospheric disturbances, as well as imperfections of lenses and mirrors, it may well be questioned whether the results could be relied upon within less than one per cent.

In the following experiments the distance between the mirrors was nearly 2000 feet. The radius was about thirty feet, and the speed of the mirror was about 257 revolutions per second. The deflection exceeded 133 millimeters, being about 200 times as great as that obtained by Foucault. If it were necessary it could be still further increased. This deflection was measured within three or four hundredths of a millimeter in each observation; and it is safe to say that the result,

having in its focus a single vertical silk fiber. The slit which is very nearly in the same focal plane as the silk fiber, is bisected by the latter, and reading of scale and circle taken. Then the screw is turned till the silk fiber bisects the deflected image of the slit, and reading taken again. The difference between the two readings gives the deflection.

The direction of rotation was right-handed. To eliminate any possible error which might arise on this account, the mirror in eight of the later observations was inverted, thus making the rotation left-handed, and the deflection was measured in the opposite direction. The results agreed well with those previously obtained with the mirror erect.

To eliminate errors due to a regular variation in speed during every revolution, if any such could exist, the position of the frame was changed in several experiments. The results were the same as before.

To test the question as to whether or not the vortex of air about the mirror had any effect on the deflection, the speed was lowered to 192, 128, 96, and 64 turns per second. If the vortex had any effect, it should have decreased with the lower speed, but no such effect could be detected. This also proves that any error due to distortion of the mirror must be excessively small, otherwise it also would have been diminished with the smaller speed, thus giving different results.

Finally, to test if there were any bias in making the observations, the readings in several sets were taken by another, and written down, without divulging them. The separate readings were as consistent as when made by myself, and the results still agreed with those of the other observations.

Results of Observations.

Every number is the mean of ten separate observations.

299710	299820	299740	299790	299790
299600	299800	299740	299710	299740
299760	299820	299740	299710	299680
299880	299800	299720	299720	299710
299740	299740	299580	299700	299660
299710	299660	299580	299670	299710
299810	299710	299480	299660	299690
299840	299740	299720	299640	299710
299840	299760	299830	299650	299770
299740	299700	299810	299660	299800
299860	299690	299740	299810	299820
299840	299650	299770	299820	299820
299790	299670	299710	299790	299710
299510	299740	299730	299760	299640
299620	299740	299740	299780	299810
299670	299690	299740	299620	299840
299860	299660	299750	299740	299780
299860	299650	299710	299750	299580
299820	299620	299740	299750	299560
299820	299660	299740	299680	299610

Mean result	299728
Cor. for temp.	+12 (of steel tape, scale and screw).
Vel. of light in air	299740
Cor. for vacuo	+80

Vel. of light in vacuo 299820 kilometers per second.

ART. XLVII.—*The Kane Geyser Well*; by CHARLES A. ASHBURNER, Assistant Second Geological Survey of Penn.*

THE Kane Geyser or Spouting Water-well, which during the past year has attracted such general attention from the "sight-seeing" public, is no novelty to the oil man. The cause of the action has been so erroneously represented, that a correct explanation seems to be demanded.

This well is situated in the valley of Wilson's Run, near the line of the Philadelphia and Erie Railroad, four miles southeast from Kane. It was drilled by Messrs. Gruhout and Taylor in the spring of 1878 to a total depth of 2,000 feet. No petroleum was found in paying quantities and the casing was drawn and the hole abandoned, since which time it has been throwing periodically—every ten to fifteen minutes—a column of water and gas to heights varying from 100 to 150 feet.

During the operation of drilling, fresh "water veins" were encountered down to a depth of 364 feet, which was the limit of the casing. At a depth of 1415 feet a very heavy "gas vein" was struck. This gas was permitted a free escape during the time the drilling was continued to 2,000 feet.

When the well was abandoned, from failure to find oil, and the casing drawn, the fresh water flowed into the well and the conflict between the water and gas commenced, rendering the well an object of great interest. The water flows into the well on top of the gas, until the pressure of the confined gas becomes greater than the weight of the superincumbent water, when an expulsion takes place and a column of water and gas is thrown to a great height. This occurs at present at regular intervals of thirteen minutes and the spouting continues for one and a half minutes. On July 31, Mr. Sheafer (aid, McKean County) measured two columns, which went to heights respectively of 120 and 128 feet. On the evening of August 2d, I measured four columns in succession and the water was thrown to the following heights: 108, 132, 120 and 138 feet. The columns are composed of mingled water and gas, the latter being readily ignited. After night-fall the spectacle is grand. The antagonistic elements of fire and water are so promiscuously blended, that each seems to be fighting for the mastery. At one moment the flame is almost entirely extinguished, only to burst forth at the next instant with increased energy and greater brilliancy. During sunshine the sprays form an artificial rainbow, and in winter the columns became incased in huge transparent ice chimneys.

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* The above notice of this remarkable water-and-gas geyser is from Stowell's Petroleum Reporter (Pittsburgh, Pa.) for Sept. 15th. The view of the Geyser is copied from a photograph sent to the editors by Mr. Ashburner. A fuller description of a similar and adjoining well by Mr. Ashburner appeared in 1877 in the Transactions of the American Philosophical Society, and is noticed in this Journal in volume xvi, at page 140, 1878.

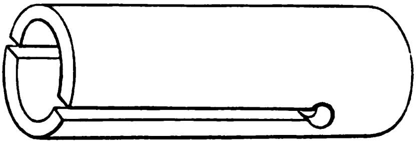
A number of wells in the oil regions have thrown water geysers similar to the Kane well, but none have ever attracted such attention.

As early as 1833 a salt well, drilled in the valley of the Ohio, threw columns of water and gas, at intervals of ten to twelve hours, to heights varying from fifty to one hundred feet. This well is possibly the first of the "water and gas geyser wells."

Art. XLVIII.—*On a Resonant Tuning Fork;* by Thomas A. Edison, Ph.D., Menlo Park, N. J.

[Read at the Saratoga meeting of the American Association.]

For the purpose of rendering audible the sounds produced by tuning forks, they are generally mounted upon resonant boxes containing a column of air whose vibrating period is the same as that of the fork. I have devised a modification of this plan, by which the box is dispensed with, the resonant chamber, as is shown in the cut, being formed by the prongs themselves. To make the fork, a thick tube of bell-metal, one end of which is closed, has a slit sawed longitudinally through its



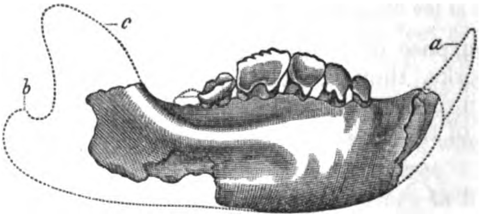
center, the slit being nearly to the closed end. This slit divides the tube equally and gives two vibrating prongs, analogous to those of a fork. To bring the prongs into unison with the column of air between them, the tube is put in a lathe and turned thinner until the desired point is reached and the two are in unison. Thereupon the sound of the fork is powerfully reinforced.

ART. XLIX.—*Notice of New Jurassic Mammals;* by Prof. O. C. MARSH.

ADDITIONAL remains of mammals from the Jurassic of the Rocky Mountains indicate that this class constituted an important element in the Mesozoic fauna of this country. The forms already described,* as well as those noticed below, show moreover, such a resemblance to known types from the Purbeck of England, that some connection between the two faunæ is clearly implied, and future discoveries will be awaited with interest.

Ctenacodon serratus, gen. et sp. nov.

One of the most interesting specimens yet brought to light is a diminutive right lower jaw, with most of the teeth in excellent preservation. This specimen differs widely from the remains hitherto found in this country, but agrees in its main features with the genus *Plagiaulax* of Falconer.† From the type species of that genus (*P. Beckelsii*), it differs in having four lower premolars instead of three; while from all the described species, it may be distinguished by the absence of the characteristic oblique grooves on the sides of the premolar crowns. This specimen is represented in the figure given below.



Right lower jaw of *Ctenacodon serratus*, Marsh; about four times natural size. *a.* incisor; *b.* condyle; *c.* coronoid process.

This lower jaw is short and massive. Its outer surface is marked by a strong ridge, which begins below the first premolar, and is continued to the base of the coronoid process.

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* This Journal, vol. xv, p. 459, 1878; vol. xviii, pp. 60 and 215, 1879.
† Journal Geological Society of London, vol. xiii, p. 261. 1857.

The symphysis is short, and the two rami were not firmly coössified. The lower dental series is as follows:

Incisors 1–1; premolars 4–4; molars 2–2.

The incisor was large, and had a compressed base. The premolars are wedge-shaped, and all have sharp trenchant crowns. The summit of each is very thin, and the last is distinctly serrated. The first lower molar had a low crown, very similar to that of *Plagiaulax.*

The following are the principal dimensions of this specimen:

Length of portion preserved	11· mm
Space occupied by lower teeth	8·5
Space occupied by four premolars	4·5
Depth of jaw below first premolar	2·5
Depth of jaw below last premolar	3·5
Height of crown of last premolar	1·5

A second specimen, also a right lower jaw, agrees essentially with the one here described. Both are from the same locality, in the Atlantosaurus beds of Wyoming. These fossils, with those of the genus *Plagiaulax*, belong to a well marked family, which may appropriately be termed *Plagiaulacidæ.*

Dryolestes arcuatus, sp. nov.

A third species of *Dryolestes* is at present represented by five specimens, two upper, and three lower jaws. This species may be distinguished from those already described by the upper and lower molar teeth, which are small, crowded together, and placed on a curve, the former with the convexity outward. The specimen which may be regarded as the type of this species is an upper jaw, with six molar teeth in place. Between these and the canine, there were at least four premolars. The teeth of the lower jaw were small, and numerous, and in one specimen appear to have been arranged on a curve opposite to that of the upper molars.

The principal measurements of the type specimen are as follows:

Space occupied by teeth in maxillary	15· mm
Space occupied by six posterior molars	7·
Height of maxillary above second premolar	5·
Space occupied by first three upper molars	3·5

The known remains of this species indicate an animal about as large as a weasel. The species now described represent a distinct family, which may be called *Dryolestidæ.*

Tinodon robustus, sp. nov.

A species of this genus, about twice as large as the one previously described (*T. bellus*), is indicated by a lower jaw with several teeth in good preservation. The lower molars have a strong basal ridge on the inner surface of their crowns. The ramus of the lower jaw is compressed. The mylo-hyoid groove is well marked, and is continued forward much further than in the smaller species.

The main dimensions of this specimen are as follows:

Space occupied by four lower molars	9·mm
Depth of jaw below first lower molar	4·
Depth of jaw below last lower molar	5·
Height of penultimate molar above inner side of jaw	2·

This specimen pertained to an animal about the size of the preceding species.

Tinodon lepidus, sp. nov.

Another species of *Tinodon*, the smallest yet found, is represented by a left lower jaw, in fair preservation. This specimen differs from the type of *T. bellus*, which it most resembles in size, in having smaller teeth, the inner margin of the jaw somewhat inflected, and the angle extending downward below the condyle, instead of being emarginate at this point. The condyle, moreover, is on a level with the base of the teeth, and not above their crowns, as in the type species.

The present specimen measures as follows:

Distance from first molar to end of condyle	15·mm
Space occupied by four molar teeth	6·
Depth of jaw below first lower molar	2·5
Depth of jaw below condyle	2·

All the specimens here described are from the same locality, in the Upper Jurassic of Wyoming, and are now preserved in the Yale Museum.

Yale College, New Haven, October 22d, 1879.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On a new method of preparing Hyponitrous acid.*—Since the method of preparing sodium hyponitrite by reducing sodium nitrite with sodium amalgam is long and tedious and the yield small, Zorn has devised an electrolytic method for producing it, which works well. At first he used platinum electrodes in a concentrated solution of sodium nitrite; but with no result. He then made the negative electrode of mercury, using four Bunsen cells. A pretty active evolution of gas begins in a short time, the gas, however, containing no ammonia. If the current be broken after a short time, the liquid neutralized with acetic acid, and treated

with silver nitrate, an abundant precipitate of silver hyponitrite, AgNO, is thrown down. If the electrolysis be continued too long, i. e., after the evolution of ammonia begins, the silver hyponitrite falls as before on adding silver nitrate to the neutralized liquid, but is immediately decomposed with evolution of gas and deposition of metallic silver. This reaction shows, therefore, the production of hydroxylamine in this electrolysis. The yield of hyponitrite is good and the author recommends this process as much preferable to that by sodium.—*Ber. Berl. Chem. Ges.*, xii, 1509, Sept., 1879. G. F. B.

2. *On the Direct Union of Calcium oxide and Carbon dioxide.*—It is well known that at a high temperature, calcium oxide unites directly with carbon dioxide, while they have no action at ordinary temperatures. BIRNBAUM and MAHN have sought to determine more exactly the temperature at which this action commences. Pure lime was prepared by igniting marble in a platinum crucible, slaking it with water repeatedly and igniting until the weight was constant. Pure dry carbon dioxide was passed over weighed portions of this lime, contained first in a boat in a porcelain tube, and afterward in a bulb of Bohemian glass, the heat being that of a paraffin bath heated from 160° to 320° C. The weight remained unchanged. Experiments made with baths of lead and tin alloys fusing at from 230° to 290°, or of pure lead fusing at 236·2°, gave the same result. The first absorption was observed when the bulb was placed in melted zinc, 415·3°. After five to eight hours, 100 parts of lime absorbed 4·1 per cent CO_2, after thirteen hours 15·2 per cent, after forty hours 31·6 per cent, and after fifty hours 45·7 per cent. Since 100 parts of lime requires 78·57 parts CO_2, but a little more than half the quantity required to form $CaCO_3$ was taken up in this time. On heating for sixty hours, only 21·1 per cent was absorbed. Hence dissociation must also take place at this temperature. To test the question, precipitated calcium carbonate was treated in a slow current of dry air in the zinc bath. After ten hours 0·78 grams had lost 0·011 grams; but farther heating did not increase this quantity. The temperature of union and of dissociation of calcium carbonate is therefore about 400°.—*Ber. Berl. Chem. Ges.*, xii, 1547, Sept., 1879. G. F. B.

3. *On the new Element, Scandium.*—CLÈVE has studied the new earth scandia, discovered by him, a few weeks after Nilson's announcement of it, in gadolinite and yttrotitanite, the former containing 0·002 to 0·003 and the latter 0·005 per cent of scandium. Scandia has the formula Sc_2O_3, ammonio- and potassio-scandium sulphates, and also the oxalates and selenites, establishing it. From eight to ten grams of scandia, by repeated decompositions of the nitrate, one gram of a white earth was obtained. This was converted into sulphate and calcined; 1·451 grams gave 0·5293 of scandia, which gives for the atomic weight of scandium 44·01. If scandia be taken as ScO, the above result gives as its molecular weight 45·94; differing essentially from 105·83 the minimum

value given by Nilson. Careful examination by Thalén with the spectroscope, proved Clève's scandia to be pure; hence he infers that in the 0·3298 gram of scandia on which Nilson worked there must have been only 0·043 of scandia and seven or eight times as much ytterbia. Clève concludes on 45 as the atomic weight of scandium. Scandia Sc_2O_3 is a perfectly white light powder, infusible and resembling magnesia. Acids, even the strongest, attack it with difficulty; still, it is more soluble than alumina. Its density is about 3·8. The hydrate is white and bulky like that of alumina. It does not attract CO_2 from the air, is insoluble in excess of ammonium or potassium hydrates, and does not decompose salts of ammonium. Its salts are colorless, with an acid and astringent taste, quite different from the sweet taste of the other yttria-earth salts. The sulphate does not give distinct crystals; but the nitrate, oxalate, acetate, and formate are crystallizable. The chloride gives no spectrum when heated in a gas flame. Its solution is precipitated by ammonium and potassium hydrates, the precipitate being insoluble in excess. Tartaric acid prevents the precipitation by ammonia in the cold. Sodium carbonate gives a precipitate soluble in excess. H_2S gives no precipitate, $(NH_4)HS$ throws down the hydrate, sodium phosphate gives a gelatinous precipitate. Oxalic acid gives a curdy precipitate which becomes rapidly crystalline. Sodium hyposulphite and sodium acetate precipitate readily boiling solutions, though incompletely. What renders the discovery of scandium particularly interesting is the fact that its existence and properties were predicted by Mendelejeff, as a consequence of his law of periodicity, and called *ekabor*. The remarkably close correspondence of the properties of ekabor with those of scandium is shown by printing them in parallel columns in Clève's memoir.—*C. R.*, lxxxix, 419, Aug., 1879.

G. F. B.

4. *On two new Elements, Thulium and Holmium.*—Since the ytterbium of Marignac and the scandium of Nilson, both of which were discovered in erbia, give colorless salts, CLÈVE has sought to distinguish the substance in this earth which gives the red color and the beautiful absorption spectrum to its salts, in order to ascertain if it was erbium itself. Using the residues from which Nilson had separated the ytterbia and the scandia, he found it impossible to obtain a red oxide with a constant molecular weight, even after several hundred decompositions. Suspecting the presence of an unknown oxide, he applied to Thalèn to examine the spectrum of what he regarded as the purest erbia, and to compare it with that of yttria and of ytterbia. Certain absorption bands in the last fractions suggested that the color of erbia is due to the presence of three oxides giving absorption spectra. The reddest of the fractions (RO mol. wt., 126–127) were united and submitted to a long series of decompositions, one fraction being treated for ytterbia, another for yttria, and a third, intermediate, containing the concentrated erbia. At the same time, he attempted to concentrate the coloring matter in residues A, rich

in ytterbia, and B in yttria. After pushing the treatment as far as possible with the amount of material in hand, he submitted the five fractions to Thalèn, who found bands common to all the fractions and hence due probably to erbia. These had the following wave-lengths: 6660–6680 (weak), 6515–6545 (strong), 6475–6515 (quite strong), 5400–5415 (quite strong), 5225–5235 (very strong), 5185–5225 (strong), 4865–4877 (strong), 4475–4515 (quite strong). The following bands varied markedly from one fraction to another:

		Fraction A.		*Erbium?*	*Fraction B.*	
	Wave-length.	Extr. from ytterbia residues.	Extr. from erbia 126–7.	Mean fractions 126–7.	Extr. from erbia 126–7.	Extr. from residues rich in yttrium.
x	6480	strong	quite strong	fails	fails	fails
y	6400–6425	fails or trace	trace	weak	weak	pretty strong
z	5360	fails	fails or trace	trace	feeble	quite strong

Hence *x* belongs to fractions situated near ytterbia and does not exist in fractions from yttrium. But, on the other hand, *y* and *z* fail in the ytterbium residues but grow sharper as yttrium is approached. The ytterbia fractions gave a rose color, with a tinge of violet; the yttria fractions had an orange tint. For the element between ytterbia and erbia, characterized by band *x* in the red of the spectrum, Clève proposes the name *Thulium*, from Thule, the ancient name of Scandinavia. The atomic weight, Tm, should be about 113 if its oxide is RO. Erbium proper, which has the common bands mentioned, has the atomic weight 110–111. Its oxide is of a clear rose color. The third metal present, characterized by the *y* and *z* bands, and which is between erbia and terbia, should have an atomic weight below 108. Its oxide appears to be yellow. For it, the name *Holmium* is proposed, derived from the Latin name of Stockholm, the environs of which are rich in yttria minerals.—*C. R.*, lxxxix, 478, Sept., 1879.

G. F. B.

5. *Notes on the two new Elements announced by Clève.*—SORET has called attention to the fact that he pointed out in the spring of 1878, the two bands which characterize holmium, as not belonging to erbia, but to a new earth which he called provisionally X and which is perhaps identical with philippium since discovered by Delafontaine. Beside these two bands, Soret recognized three other absorption bands; one less refrangible than A, a second overlapping the band of erbia in the indigo, and a third, faint, in the violet a little beyond *h*. In the ultra violet-spectrum six absorption-maxima exist from H to R. In samarskite, the earth X is, relatively to erbia much more abundant than in gadolinite. As to the red ray which characterizes thulium, Soret had already observed that also in some ytterbia products which had been sent to him for examination by Marignac. LECOQ DE BOISBAUDRAN confirms Soret's statement in regard to the red thulium ray, hav-

ing observed it in a sample of impure ytterbia which he had received from the latter some months ago. He inclined to the belief that all the bands were due to erbia, modified by the conditions. But special experiments led him to coincide in Soret's views and to conclude in the possibility that erbia was a mixture of three oxides.—*C. R.*, lxxxix, Sept., 1879. G. F. B.

6. *An Introduction to the Practice of Commercial Organic Analysis;* being a Treatise on the properties, proximate analytical examination, and modes of assaying the various organic chemicals and preparations employed in the Arts, Manufactures, Medicine, etc. With concise methods for the Detection and Determination of their Impurities, Adulterations and Products of decomposition; by ALFRED H. ALLEN, F.C.S., Lecturer on Chemistry at the Sheffield School of Medicine, etc. Volume I. Philadelphia, 1879. (Lindsay & Blackiston.)—In preparing this book, Mr. Allen has done a good service for the public analyst. The great activity in organic research in recent years has resulted in the production of a large number of compounds whose valuable properties have led to their commercial utilization. Except, however, in the original memoirs where they were described, the properties and reactions of many of these compounds have remained comparatively unknown, and hence their adulteration has been an easy matter. In gathering together the physical and chemical properties of these substances into a convenient volume, and especially in doing this with the care and scientific accuracy which Mr. Allen has evidently exercised, a valuable aid has been rendered in protecting the public from imposition. The volume before us is the first of two which the author has projected. After a brief introduction, in which are given the methods of the preliminary examination of organic bodies, the study of their physical properties, their solubility in various menstrua, their ultimate or elementary analysis, and the production of definite compounds from, and the products of decomposition of, organic bodies, the author takes up several classes of these organic bodies in the following order: Cyanogen and its derivatives, alcohols, neutral alcoholic derivatives, acid alcoholic derivatives and vegetable acids, phenols, and the acid derivatives of phenols. The individual members of each class which are of commercial importance are, in general, quite fully considered, their origin, mode of preparation, physical and chemical properties, reactions, and adulterations, being discussed in order. This portion of the work appears to be entirely reliable, and leads us to hope that the second volume may soon be forthcoming. In reproducing it here, the American publishers have strengthened the cause of sanitary chemistry in this country.

G. F. B.

7. *Laboratory Teaching:* or Progressive Exercises in Practical Chemistry; by CHARLES LONDON BLOXAM, Professor of Chemistry in King's College, London, etc. Fourth Edition, with eighty-nine illustrations. Philadelphia, 1879. (Lindsay & Blakiston.)—Chemical text-books may be divided into two classes,

those which teach Chemistry as a science and aim to make chemists, and those which teach it as an art and aim to make analysts. Professor Bloxam's book, to judge from the somewhat extraordinary preface to the fourth edition, belongs evidently to the latter class. He says: "The most important alteration in the present edition is the introduction of the formulæ representing the various chemical compounds described in the notes to the tables. The formulæ are those now generally employed by chemical writers and teachers in this country. The verbal description of the composition, in the Tables of Common Compounds of the several metals, has not been altered so as to bring it into perfect harmony with the formulæ, since the description there given generally informs the learner what substances can be obtained by the decomposition of the Common Compounds which is not so easily to be ascertained by an inspection of the formulæ. For example, the composition of saltpeter is described at page 81 as Potash (Potassium and Oxygen) and Nitric Acid, while the formula KNO_3 does not indicate the presence of potash (K_2O) or of nitric acid (HNO_3); but both these substances are obtainable from saltpeter by very simple chemical operations, and saltpeter may be produced by causing them to act upon each other. It is true that similar reasoning would justify the statement that common salt contained soda and hydrochloric acid instead of sodium and chlorine, but the author feels that an endeavor to be absolutely consistent would injure the practical usefulness of so small a book." Hence we are not surprised to find that Na_2SO_4 is called sulphate of soda and that it is said to be composed of soda and sulphuric acid; or to be told that sulphate of ammonia $(NH_4)_2SO_4$, is composed of ammonia, water, and sulphuric acid. In the first edition, it is claimed as a merit that the book "does not enter into any theoretical speculations." In the light of the preface to the fourth edition and of the instances just quoted, we have to differ from that opinion, reminding the author that unexploded theories are less dangerous to teach, than exploded ones. Viewed from the author's stand-point, however, the book has some good points. The methods of manipulation are well described and illustrated, the leading reactions of the more commonly occurring substances are clearly given, and the processes for the qualitative determination of unknown mixtures are plainly tabulated. The mechanical execution of the book is excellent. G. F. B.

8. *Solar Physics.*—On the occasion of the partial eclipse observed at Marseilles on the 19th of July, 1879, M. JANSSEN applied the photographic method of observing contacts. The observation of partial eclipses have long been considered inaccurate for the determination of position; the difficulties of taking precise micrometric measurements upon the sun and the determination of the instant of contact are well known. M. Janssen proposes to take, by means of a *revolver*, a number of solar images of $0^m{\cdot}06$ to $0^m{\cdot}10$ in diameter, at intervals of one second. By optical methods the contacts cannot be observed with precision, on

account of the small deformation of the solar disc, when the moon encroaches upon it. With the *revolver* one can obtain a series of negatives which include the critical moment of contact. These negatives can be examined at leisure. These photographs also can be used to determine the relative position of the two heavenly bodies at the different intervals of time, and by this means check the above method of observing contacts. The method is also of use in studying the character of the sun's surface. If the moon's disc is absolutely free from a gaseous envelope, the solar granulation preserves its forms and its character up to the edge of the occulting moon. If, however, a gaseous envelope of considerable size interposes itself, it will act under the most favorable conditions for producing these deformations by refraction. The existence and the value of these deformations of the granulations at the edge of the occulting moon will therefore become a very sure test of the presence and density of this atmosphere. This method also allows of the determination of the height of the lunar mountains situated on the edge of the moon's limb, in a position where the methods of measurement hitherto used have been the most difficult and the most inexact. The photographs of the edge of the sun upon which the moon's limb encroaches gives the contour of all the inequalities of the surface of the moon which are projected upon the sun. By micrometric measurements and comparison with the sun's disc, one can readily obtain the relative size of these inequalities of surface. These measurements together with those of the angles they subtend, as seen from the earth, afford the means of obtaining their true size. This method of observation was employed on the occasion of the late eclipse at Marseilles. Some solar photographs $0^{m}\cdot30$ in diameter were taken. These photographs show the granulations; but do not give any evidence of a change on the moon's limb. They however show very clearly the inequalities of the lunar contour, and allow of micrometric measurements of the heights of these inequalities.—*Comptes Rendus*, No. 6, 1879, p. 340. J. T.

9. *Density of the light Ether.*—Herr P. GLAN criticizes the conclusions of Sir William Thomson that the mass M of a cubic foot of ether is greater than $\frac{83g}{V^2 n^2}$ pounds, where g is the gravitation constant, V the velocity of light, and n the ratio of the greatest velocity of a rotating ether particle to the velocity of light. The value of n taken by Thomson is $\frac{1}{50}$ and the resulting value of M is greater than $\frac{1}{1560\cdot1017}$ pound. According to Thomson it lies in the nature of wave-movement that the ratio of the greatest velocity of a swinging particle to the velocity of light must be small, and if the ratio $\frac{1}{50}$ is taken the resulting value of M must be below the true value. Herr Glan, from theoretical conclusions upon the limit of actual disruption of the ether, doubts the conclusions of Thomson. The passage of the heavenly bodies through the ether of space must tend to separate the ether particles, and since the ether offers no sensible opposition to the pas-

sage of these bodies, it is concluded that very little energy is needed to effect any separation of ether particles which may take place, and the greatest possible dilatation of this ether must be much smaller than is the case with glass or water. In comparing authorities, Herr Glan finds that taking the greatest possible dilatation of glass before disruption at $\frac{1}{1443}$ the value of $n=\frac{1}{37}$ which is twice the value taken by Thomson. For the greatest possible dilatation of water under the same conditions, the value of $\frac{1}{37\cdot106}$ is taken. This gives the value $n=\frac{1}{4306}$ if the dilatation of the ether before disruption is as great as in the case of water. This value of n shows that the ether in a definite space possesses more mass than the hundred billionth part of this space, if it were filled with hydrogen at its normal density. The lower limit of the density of ether, according to this calculation, would therefore be 7416 times greater than that given by Thomson.—*Annalen der Physik und Chemie*, No. 8, 1879, p. 640. J. T.

10. *Mechanical Equivalent of Heat.*—H. CARNOT has presented to the French Academy a series of his brother Sadi's manuscripts written between 1824 and 1832. From these papers it appears that Sadi Carnot had discovered the mechanical equivalence of heat and work. The following is an extract from these papers: "Heat is then the result of a movement. It can be produced by the consumption of motive power, and it can produce this power. When there is destruction of motive power, there is at the same time a production of heat exactly equivalent to the motive power destroyed. Reciprocally when there is destruction of heat there is production of motive power. According to some ideas which I have formed upon the theory of heat, the production of a unit of motive power necessitates the destruction of 2·70 units of heat." The unit of work taken is that which will lift one cubic centimeter of water one meter high. This unit is 1000 kilogrammeters. The mechanical equivalent of heat, according to this, would be $\frac{1000}{2\cdot71}$ $=370$ kilogrammeters. The first determination of Mayer in 1842 gave 365 kilogrammeters. Joule's result is 425. The publication of this result of Carnot was prevented by his death, which occurred at the early age of 36.—*Beiblatter*, *Annalen der Physik und Chemie*, No. 8, 1879, p. 584. J. T.

11. *Units and Physical Constants;* by Professor J. D. EVERETT. 175 pp., small 8vo. London, 1879. (Macmillan & Co.).—The author of this work was the Secretary of the Committee of the British Association appointed with reference to "the selection and nomenclature of dynamical and electrical units." In 1875 he prepared a volume of illustrations of the C. G. S. system (or centimeter-gram-second system) of units, adopted by this Committee, and of this volume the present work is substantially a second edition. It appears, however, in a much enlarged form, and under a different name. The importance to the physicist of having the many physical constants referred to a uniform series of fundamental units can hardly be over-estimated, and hence the great value of Professor Everett's book, in which this end is accomplished.

12. *Elementary Lessons on Sound;* by Dr. W. H. STONE. 191 pp. 12mo. London, 1879. (Macmillan & Co.).—The fundamental principles of Acoustics are fully and clearly stated and illustrated with numerous figures and practical examples. From them the author passes to the development of the theory of music, and explains it, so far as space permits, in a very clear and satisfactory manner. He makes use of the results of the more recent investigations in this field, and thus puts within the reach of the student much that would otherwise be inaccessible to him.

II. GEOLOGY AND MINERALOGY.

1. *On some points connected with the igneous eruptions along the Cascade Mountains of Oregon;* by Rev. THOMAS CONDON. (From a letter to J. D. Dana, dated Eugene City, Oregon, July 1, 1879.)—[The letter was written in reply to an inquiry respecting the continuity of the lavas of Mt. Hood and the Cascade Region with those of Mt. Adams and Mt. St. Helens, and relating to other points bearing on the extent of the eruptions southward along the Cascade range.—J. D. D.]

The Cascade range from Klamath River, south of the Columbia, to Mt. Rainier, on the north, has somewhat of the outline of a prostrate tree, far gone to decay. The main trunk is well represented by the main range; and at almost regular intervals along the whole line, we find, lying by its side, the remnants of its former limbs; not entire limbs now, but the knots that survive to represent them. Beginning at the north we find in the Simcoe Mountains, directly east of Mt. Adams, an evident outflow of eruptive material from that center; tilted and broken, yet in line. Twenty-five or thirty miles south of Simcoe Mountain, we find another such in the Klikitat Mountain; at the foot of which flows the Columbia River, and by whose help and guidance, the Columbia was enabled to penetrate and break through the range itself at the Cascades. This Klikitat Mountain is 2,000 feet high, and its beds are warped and tilted, showing that, like the Simcoe Mountain, it was subjected to the full measure of the violence that here closed the Miocene Tertiary. Thirty miles south of this is another elevation, known here as the Des Chutes Hill. This, too, is basalt, flexed and tilted, and broken, yet continuous; an evident outflow from the neighborhood of Mt. Hood.

Others may be traced farther south. Now all these hills have the following common characteristics: first, they are of eruptive origin; secondly, the dip is regularly away from the main range, from whose summit or sides they once flowed; thirdly, the dip they all have indicates a higher source of outflow than the present altitude of the range could give. They are just what they would be if the places they now occupy had once been the excavated valleys of streams of a higher level than our present ones, into which great lava streams flowed, displacing their waters, and thus transferring their eroding power from old ravines to the softer sediments around them, till the ravine full of lava became a mountain, and its former banks deeper excavations. These transverse lines of hills as seen from a point fifty or sixty miles away show a fine series of accordant lines in perspective, very suggestive of similarity of origin.

At the close of the period, in the geology of the Cascade region, represented by the facts mentioned: First, there existed the main range, here running north and south, and at a much higher altitude than the present; second, a series of offshoots from the range less in altitude than the range itself; and third, a series of deep and extensive interspaces excavated in the older softer sediments, in relation to which these basaltic offshoots became future partitions.

Now one of the largest of these offshoots, situated between Mt. Hood and Mt. Adams, is the Klickitat Mountain, which breaks the continuity of all eruptions after the commencement of the Pliocene or thereabouts.

As to the history of the deeply excavated interspaces, we may take the one nearly east of Mt. Hood. The Des Chutes Hill, one of these offshoots already described, is its northern barrier, and we may make it our standard of record. That this excavation was once 2,000 feet deeper than it is now is proved by the two facts that, first, the Des Chutes River has cut its channel through its present filling of basalt without reaching the bottom, and secondly, that this great thickness of rock lies in undisturbed and unbroken level. Twenty-six to thirty distinct outflows may be counted in the section, at the crossing of the Des Chuttes River. This later basalt is dark in color, dense in structure, and easily distinguished from the basalt of the neighboring hill, which has a brown color and is lighter. These later outflows filled up this vast excavation, then spread eastward and northward till they reached the outlying elevations of the foothills of the Blue Mountains. A well defined belt of sedimentary rock marks the strictly eastern limit of this outflow along the line of Antelope Valley and the John Day River. The nearest centers of eruptive outflow, other than those of the Cascade Range here, would be from the western spurs of the Blue Mountains. The largest of these was an eruption from the neighborhood of Camp Watson. It flowed into what seems to have been the old meandering valley of the John Day River. It appears to have filled up the valley and set the waters to excavating a new one for themselves. This old valley full of basalt is now a mountain 1,200 to 1,500 feet above the plane. The mold in which its mass was cooled has long since been washed or quietly worn away. This Blue Mountain basalt can easily be distinguished from that of the Cascades. It is filled with granulations of a dark green pyroxene that gives its weathered surfaces a pustulated appearance.

The undisturbed basalts that have filled up those vast excavations constitute a *second* series of operations in the region.

The diminished eruptions of later times make another group of facts, and in the respective fields of Mt. Hood and Mt. Adams they differ widely. It is as if the eruptions from Mt. Adams had ceased in times of strong currents of lava, while those of Mt. Hood continued till recent times, with less and less of dense materials, and a vast increase in showers of ashes, and outflows of volcanic mud.

The limited amount of examination I have myself given the summit line of the Cascade Range hardly entitles me to state how far the interval between Mt. Hood and Mt. Shasta is covered with eruptive rocks. But if I should judge from the materials brought down in the beds of its streams, and the rocks I have gathered at points where I have crossed the summit, I should say nearly the whole. This answer will not seem so improbable if we remember that our present snow peaks, Hood, Jefferson, The Sisters, Dimond, Scott and Pitt, are only a few of the volcanic vents between Hood and Shasta. These named only mark recent vents, and not even half of these. Many older vents have been covered up.

Two years ago I felt intensely interested in the examination of one of the more recent deposits of the Cascade Range, a short description of which I will add here. This deposit was the result of an immense shower of volcanic ashes. The point at which I crossed it is perhaps midway between Hood and Shasta. Of course these showers of ashes would drift eastward of the summit, for the prevailing winds there are westerly. We encountered them six or eight miles west of the summit. The volcanic ashes were evenly laid over the whole surface, like a covering of snow. East of the summit there was a marked increase in its quantity, so much so, that the sharp features of the older surface ceased to show themselves through it. We traveled over it for a distance of fifty or sixty miles, noticing that as we receded, from the Cascade Mountains, its materials were finer and its bulk less.

Eastward from Mt. Rainier this volcanic ash is everywhere mixed in large quantity with the Pliocene deposits of the Yakima Valley. Around Mt. Adams it is almost entirely absent. It abounds again eastward of Mt. Hood. Former lake widenings of the Columbia around The Dalles show this material stratified, and containing fine impressions of late Tertiary leaves, although deposited 200 feet above present waters. The amount of this volcanic ash, upon the eastern slope of the Cascade Mountains, is enormous, and helps conceal from the observer the rocks below. It has in it cementing material, so that a fall of rain upon it seems to have been sufficient to prevent its subsequent drifting.

2. *Bulletin of the U. S. Geological and Geographical Survey of the Territories* (under F. V. HAYDEN, as Geologist-in-charge.) Vol. V, No. 2. 180 pp. 8vo.—This new number of the Bulletin contains the following papers: on the Coatis, by J. A. ALLEN; on the present state of *Passer domesticus* in America, and Second Installment of American Ornithological Bibliography, by Dr. E. COUES, U. S. A.; on the Laramie Group of Western Wyoming and the adjacent regions, by A. C. PEALE; on Litho-

phane and new Noctuidæ, by A. R. **Grote**; on certain Carboniferous fossils from Colorado, Arizona, Idaho, Utah and Wyoming, and Cretaceous corals from Colorado, together with descriptions of new forms, by C. A. **White**; on the so-called Two-ocean pass (Plates 3 and 4), by F. V. **Hayden**; on the extinct species of Rhinoceratidæ of N. America and their allies, by E. D. **Cope**.

Mr. White here illustrates anew the fact that in the Western Territories the Subcarboniferous, Carboniferous and Permian, making together a series 4,000 or 5,000 feet thick, have no distinctive fossils, but instead, a commingling of the species elsewhere characterizing them; and only occasionally do new species in the lower beds point to a Subcarbonaceous age. It is also true, as a rule, that the Devonian and Upper Silurian are absent in all that great region;" and when all evidence of the presence of the Subcarboniferous fails, it is probable that this division is likewise "absent and from one and the same cause or from similar causes." As to the Permian, its *time* is probably represented by the upper strata, but no Permian fossils occur in it that do not also occur in the great mass of Carboniferous strata beneath. So far as invertebrate fossils are concerned, there is great uniformity throughout; and the prevailing characteristics as to fauna are those of the Coal-measures and especially the Upper Coal-measures of the Mississippi basin.

3. *On Stromatopora*, by H. J. **Carter** (Ann. Mag. Nat. Hist., V, iv, 253, 1879.)—Mr. Carter, in this third article on Stromatopora, points out the close relation of these corals in structure to the coralla of Hydractinia and Millepora, and thus sustains the Hydroid affinities of the group. The paper is illustrated by a plate representing sections.

4. *Note on the Section by Mr. T. Nelson Dale on page* 293 *of this volume;* by Dr. S. T. **Barrett**. (Communication dated Port Jervis, N. Y., Oct. 8, 1879.)—In the section by Mr. Dale, No. 5 is Hall's *Stromatopora Limestone*, and is the same as the *Favosite Limestone*, No. 2 (five feet thick), of my paper in vol. xiii, May, 1877, of your Journal. The name Favosite limestone is a synonym for Hall's Stromatopora limestone, and has long been dropped by me. No. 1, "Encrinal limestone," of the same paper, is undoubtedly the equivalent, or, more properly speaking, the continuation of Hall's Coralline limestone, which I think I have made out to be the equivalent of the Niagara limestone; at least, Whitfield recognized in it, at Nearpass Quarry, *Halysites agglomeratus*, *Favosites pyriformis*, *Cladopora seriata*, *Cyathophyllum Shumardi*, and *Rhynchonella pisa*, along with several Coralline limestone species. See this Journal, vol. xv, 1878.

5. *Geological Atlas of the State of Ohio.* Prepared by J. S. **Newberry**, Chief Geologist, and E. B. **Andrews**, E. **Orton**, M. C. **Read**, G. K. **Gilbert**, N. H. **Winchell**, F. C. **Hill**, Assistant Geologists. Published by authority of the Legislature of Ohio. 1879.—This atlas, published as embodying the results of the recent Geological Survey, is in six large sheets, and presents the distribution of the formations in colors. It is a very handsome

map in its style of publication, and of great interest geologically. Like the Wisconsin map and some other recent geological atlases, it is very large, much larger than the amount of detail upon it made necessary; and, therefore, those having to consult it might well say, too large. Still the science of the land is greatly indebted to the liberality of the State of Ohio, and to its geologists, for this and all the publications of the Survey.

Some points in the details of the part of the map relating to the section of the State under the charge of Professor E. B. Andrews are not in accordance with his conclusions; and since he had no part personally, as he states, in the preparation of the map, his proposed corrections, recently received for this Journal, are here annexed.

"(1.) The Lower Carboniferous limestone— the Maxville limestone of my reports—is represented on the map as having a continuous outcrop, forming, with but a single short break, a continuous belt more than four hundred miles long, around the sinuous margin of the Coal Measures. In my investigations in this district, where I have long lived, I have found the Lower Carboniferous limestone only in the few localities mentioned in the Reports; and always in limited patches. The limestone belt of the map crosses the paths of Professor Orton in Pike County, Professor M. C. Read in Licking County, and Professor Stevenson in Muskingum, but none of these field-workers saw it, and their detailed geological sections give no hint of it. (2.) The Conglomerate at the base of the Coal Measures reported by Professor Orton in Pike County, and by myself in Jackson County, is omitted from the map. (3.) According to the map, the Waverly rocks, for a considerable distance, rest upon the Silurian rocks of the Cincinnati uplift without any intervening Devonian Black shale—the Huron shale of Dr. Newberry. This is not far from the eastern line of Adams County. My report for 1869, and the preliminary map give the belt of Black shale in its proper location, for 'it is finely exposed,' to quote from the report, 'in the Ohio River hills in the neighborhood of Rockville, Adams County, and in nearly all the hills which range to the north.' The final map represents the existence of the Black shale at Portsmouth and in the valley of the Scioto River above, where my searches only revealed Waverly rocks; but if there, the shale, rising to the westward, passes over a hilly mass of Waverly sandstone, and according to the map never comes out in any western outcrop."

6. *Geological Survey of Canada: Mesozoic Fossils*, Volume I, Part ii, *on the Fossils of the Cretaceous Rocks of Vancouver and Adjacent Islands in the Strait of Georgia;* by J. F. WHITEAVES, F.G.S., Palæontologist to the Survey. 100 pp. 8vo, with 10 lithographic plates. Montreal, 1879.—The Cretaceous fossils are from the southeastern part of Vancouver Island, and pertain to two Coal-fields, the Comox and the Nanaimo. In the former, the thickness of the whole series is 4,912 feet, and that of the productive Coal-measures, 739½ feet; while in the latter, the whole

thickness is 5,266 feet, and that of the productive measures, 1,316 feet.

7. *On the Structure and Affinities of the Tabulate Corals of the Palæozoic Period, with critical descriptions of Illustrative Species;* by H. Alleyne Nicholson, Prof. Nat. History, Univ. St. Andrews. 338 pp. 8vo, with 15 plates. Edinburgh and London. 1879. (William Blackwood & Sons.)—Professor Nicholson has had opportunities in America as well as in his own land for the study of fossil corals, and has devoted much of his time for several years to the subject. The present work is the fruit of a large amount of careful study with the aid of microscopic sections, and many interesting results are brought out, as is exhibited on the several lithographic plates. On account of the abundance in this country of the corals treated of, the critical character of the work, and the comparisons made of American and European species or varieties, the work has special interest for both hemispheres. He states, as the general result of his investigations, that his labors corroborate the views of Verrill and Landström as to the necessity of abolishing the "Tabulata" as a separate division, and lead to the conclusion that under this old name there are included at least twelve distinct groups of corals.

8. *The Journal of the Cincinnati Society of Natural History*, vol. ii, No. 1, April, 1879.—Contains: Remarks on the genus *Poterocrinus*, by A. G. Wetherby; Descriptions of new species of fossils from the Lower Silurian about Cincinnati, by E. O. Ulrich; Remarks on the Kaskaskia Group and descriptions of new species of fossils from Pulaski Co., Ky., by S. A. Miller; Catalogue of plants growing in the vicinity of Cincinnati, by J. F. James. It is illustrated by two Plates, 7 and 8; and the first species illustrated on plate 7 is the remarkable Crustacean, *Enoploura balanoides*, named by Meek, but first rightly understood and described by Mr. Wetherby. The price of the number is only 60 cents; of the volume $2.00.

9. *On the Old Red Sandstone of Western Europe*, by Archibald Geikie, F.R.S., Director of H. M. Geological Survey of Scotland, etc. Part I, 108 pp. 4to. From vol. xxviii, Trans. Roy. Soc. Edinb., 1878.—This memoir contains a general review of the facts connected with the "Old Red Sandstone," largely from personal investigations by the author, and a discussion of the changes in the physical geography of Western Europe which took place between the close of the Upper Silurian and the commencement of the Carboniferous period. It is illustrated by maps and sections.

10. *Outlines of Field Geology*, by Archibald Geikie. 216 pp. 12mo. London, 1879. (Macmillan & Co.)—This volume is intended for the guidance of the learner in field geology, and will be found a convenient manual. Professor Geikie's own labors in the field enable him to give instruction of much value on all points connected with the subject. Some will wish that it were more extended.

11. *Reports and Awards, Group I, International Exhibition*, 1876, edited by Francis A. Walker, Chief of the Bureau of

Awards. 486 pp. 8vo. Philadelphia, 1878. (J. B. Lippincott & Co.).—Group I was that including ores and mineral products, building stones, marbles and other useful and ornamental stones; also implements and machinery used in connection with the same, and various statistics relating to them. The volume contains reports by J. S. Newberry, W. S. Keyes, J. Lowthian Bell, T. Sterry Hunt, Frederick Prime, Jr., A. L. Holley, J. M. Safford, John Fritz, M. Addy, G. C. Broadhead, E. Althaus, L. Simonin and others; and in them there is a large amount of valuable information.

12. *Mémoire sur la Structure et la composition Minéralogique du Coticule*, par A. Renard, S. J., Conservateur au Musée Royal d'Histoire Naturelle de Belgique. 44 pp. 4to. Brussels, 1877. (Mèm. Cour. Acad. Roy. Sci., Belgique, vol. xli.)—The author of this memoir proves by his investigations, that the fine yellowish whetstone, making the best of hones for razors, which is quarried at Salm-Château, Lierneux, Sart, Bihain and Recht, in Belgium, consists of massive manganesian garnet. It occurs in beds four to forty inches thick, in a slate, as a part of the slate formation. The characters of the beds are described in detail in the memoir. The composition of the whetstone of Recht, according to Dr. von der Mark (1) and M. Pufal (2), is as follows:

	SiO_2	TiO_2	$\bar{A}lO_3$	$\bar{F}eO_3$	FeO	MnO	MgO	CaO	Na_2O	K_2O	
1.	48·73	*tr.*	19·38	2·42	....	21·71	....	0·28	1·57	3·51	loss 2·40, F tr=99·88
2.	46·52	1·17	23·54	1·05	0·71	17·54	1·13	0·80	0·30	2·69	H_2O 3·28, CO_2 0·04, P_2O_5 0·16, S 0·18, organic matter 0·02=99·13

The slate, which is feebly metamorphic, is a damourite slate or schist; and the potash of the analyses is attributed to the presence of this mica in the whetstone. In microscopic sections the rock appears to consist of very minute granules—more than 100,000 in a millimeter-cube, and they show sometimes the form of the rhombohedron. In view of the form and the composition the conclusion is reached that the whetstone is a compact manganesian garnet or spessartine. This is sustained also by the specific gravity, which is 3·22, according to M. Pufal.

The occurrence of garnet in the "phyllade oligistifère" of Recht, an associated rock, was previously recognized by Zirkel.

M. Renard examined whetstones of other localities without finding a similar constitution; among them, the whetstone of Arkansas, which proved to be wholly quartzose, as had been shown by the analysis of Owen. The memoir is illustrated by a colored plate of microscopic sections.

13. *Report on the Minerals of some of the Apatite-bearing Veins of Ottawa County, Quebec, with notes on miscellaneous Rocks and Minerals* (1878); by B. J. Harrington, Ph.D. 52 pp. 8vo. Montreal, 1879. (Geol. Survey of Canada).—Dr. Harrington describes the apatite deposits of Ottawa County as occurring most commonly in connection with rocks, which consist almost exclusively of pyroxene, though quartz and orthoclase

are often present, as also mica and minute garnets. When the pyroxene is the principal mineral the rock shows little trace of bedding, but is often much jointed and sometimes has the appearance of massive eruptive rock. Other rocks of the same phosphate region are gneisses, quartzites, and crystalline limestones. The apatite occurs in many cases in connection with pyroxene in what are regarded as true fissure veins. These veins have sometimes a banded structure, but in general are characterized by a want of regularity; the apatite crystals often show proof of having been broken and re-cemented. At some localities the apatite is chiefly in crystals, often of great size, "a foot or more in diameter and several feet in length, and weighing hundreds of pounds." The edges of the crystals are often rounded. At other localities, on the other hand, it is almost wholly massive, varying from compact or crypto-crystalline to coarse-granular; a friable saccharoidal variety is common. One mass of a sea-green variety is described which "as exposed measured nearly twenty feet across, and in the whole thickness was apparently free from other minerals with the exception of a few crystals of pyroxene and mica." The color of the mineral varies through many shades of green to sky-blue, red, brown, yellow and white. The specific gravity of a dark-green glassy crystal from the Grant Mine in Buckingham was found to be 3·2115.

A list of thirty species occurring in the apatite-veins is given, some of the most important of which are: calcite, quartz, pyroxene, hornblende, phlogopite, garnet, black tourmaline, titanite, zircon, orthoclase, scapolite. Of the associated minerals the most abundant is pyroxene, the commonest variety being an aluminous sahlite, but a light-colored variety is also common. An analysis of a blackish-green crystal afforded:—

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	ign.
G.=3·385	51·28	2·82	1·32	9·16	0·33	23·34	11·61	0·17=100·03

Other varieties also occur, sometimes in crystals of large dimensions.

The pyroxene is often partially or wholly altered to uralite. The change appears to have begun at the surface of the crystal and gradually extended inward; at the surface the hornblende prisms are mostly parallel to the vertical axis, within they run in all directions and are sometimes in radiating groups. One crystal had a center of glassy pyroxene (A), surrounded by a dull pale material (B), and this by an aggregation of hornblende (uralite) prisms (C). Analyses of these three portions afforded:—

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	CaO	MgO	K_2O	Na_2O	ign.
A.	50·87	4·57	0·97	1·96	0·15	24·44	15·37	0·50	0·22	1·44=100·49
B.	50·90	4·82	1·74	1·36	0·15	24·39	15·27	0·15	0·08	1·20=100·06
C.	52·82	3·21	2·07	2·71	0·28	15·39	19·04	0·69	0·90	2·40= 99·51

The specific gravity was for A=3·181, for B=3·205, and for C=3·003. The change in composition from A to C is seen to consist principally in the loss of lime and gain in magnesia, though there is also a loss of alumina and slight gain in alkalies.

Dr. Harrington also discusses the relations of the phosphate region of Ottawa County to the Apatite-bearing veins of Norway described by Brögger and Reusch (ZS. G. Ges., xxvii, 646, 1875). There is a general similarity in the associated minerals and in other respects, but the apatite in Norway is described as occurring in an eruptive rock (gabbro), the crystals having been rounded by partial fusion. The latter part of Dr. Harrington's Report contains descriptions and analyses of a manganiferous calcite, of chrysolite, of some diorites near Montreal, and other points of interest. E. S. D.

14. *Die Pseudomorphosen des Mineralreichs; vierter Nachtrag* von Dr. J. Reinhard Blum. 212 pp. 8vo. 1879. Heidelberg. (Carl Winter).—Sixteen years have passed since the preceding appendix (the third) to his important work on the Mineral Pseudomorphs was published by Professor Blum. The many friends of the veteran author will rejoice that his life and strength have been spared so long, and that he has been able to add another important contribution to a branch of mineralogical science which owes its distinct existence to his labors. The general recognition of interest attached to the study of the changes in the chemical composition of minerals is shown by the large number of published researches which have had this as their subject; the number of pseudomorphs described in the original work (1843) was 164, and this has since been increased to 436. The present volume contains all the cases which have been described since the appearance of the last appendix. The 200 pages devoted to them is a proof of their number and the care with which the author discusses them. E. S. D.

III. Botany and Zoology.

1. *Electrical Currents in Plants.*—In a notice of the action of *Dionœa* and other irritable plants, published soon after the popular exhibition of the electrical phenomena attending the movement, said to be similar to those attending the contraction of a muscle, we threw out the suggestion that these remarkable phenomena were not unlikely to be explained away. The suggestion was founded on some investigations and trials made in the botanical laboratory of Harvard University by Professors Goodale and Trowbridge, which were never published, there being an intention to follow them up later. It appears that Kunkel has taken up this investigation and reached the same result, in the laboratory at Würzburg. His paper,* as abstracted by Micheli in Arch. Sci. Phys. and Nat. for Sept., 1879, announces that he does not admit the existence of any electrical tension in the intact tissues of the plants in question, but he concludes that the currents developed upon spontaneous movement, and similarly upon artificial curvature, are due to movements of the liquid in the cells caused by mere contact with the electrodes, or by either active or passive movements of the organs. A. G.

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* Ueber electromotorische Wirkungen an unverletzen lebenden Pflanztheilen.

2. *Adnotationes de Spiræaceis*, auct. C. J. MAXIMOWICZ. (Seorsim impressæ ex Actis Horti Petropolitani, tom. vi.) Petropoli, 1879, pp. i–xii, and 105–261, 8vo.—This is one of the most considerable botanical papers of the time. It will require to be carefully weighed before its conclusions are either rejected or adopted. Dr. Maximowicz separates the *Pomaceæ* from the *Rosaceæ* (these including the *Amygdaleæ* or *Pruneæ*), and, reducing the value of adhesion of calyx-tube with the gynœcium (to which we cannot in principle object), refers his *Spiræaceæ* to the order *Pomaceæ*, and divides the order into two families, *Pomaceæ* proper, with a succulent-fleshy calyx-tube which is usually connate with the carpels, and *Spiræaceæ* with an herbaceous calyx-tube, free from the dehiscent carpels. The order thus constituted is regarded as intermediate between *Rosaceæ* and *Saxifragaceæ*. The Linnæan *Spiræa*, which must be allowed to be composite and which included four Tournefortian genera, is distributed among the tribes of the first two orders.

The *Spiræaceæ* are divided into several tribes: the *Spiræeæ*, with carpels when isomerous with the sepals alternate with them, containing *Aruncus*, *Eriogynia* (preferred to *Lutkea*, though possibly, and we suppose without much doubt, not quite so old), *Spiræa* (of the sections *Petrophytum*, *Chamædryon*, and *Spiraria*), and *Sibiræa* (*S. lævigata* L.); these have little or no albumen and thin coat to the seed: *Neillieæ*, differing in having a smooth and stony seed-coat and very distinct albumen (*Physocarpus*, *Neillia*, *Stephanandra*, under which arrangement the separation of the first two seems most proper): *Gillenieæ*, with the carpels opposite the sepals when of the same number, otherwise nearly with the characters of the preceding; this includes *Sorbaria* (Lindley's *Schizonotus*), *Chamæbatiaria* (horrid name for a genus, taken from the sectional name given by Professor Porter to *Spiræa Millefolium* Torr.), *Spiræanthus*, of a single Siberian species, and *Gillenia*; finally the *Quillaieæ*, with winged seeds, the first genus of which is *Exochorda*. To *Rosaceæ*, as here limited, Maximowicz refers *Filipendula* (including *Spiræa filipendula*, *Ulmaria lobata*, and the like), excluded from the *Spiræeæ* and included in the *Sanguisorbeæ* on account of their indehiscent and one-seeded (biovulate) carpels; and *Holodiscus* of Koch (composed of *Spiræa discolor* and the Andine *S. argentea*), which is referred to the *Potentilleæ*, along with *Cercocarpus*, *Cowania*, and *Fallugia*, with the remark that its biovulate achenia ally it to the *Rubeæ*. Of *Rubus* it is said that the seeds are distinctly albuminous; and *Kerria*, *Neviusia*, and *Rhodotypus* are placed among the *Rubeæ*. A. G.

3. BOISSIER, *Flora Orientalis*, vol. iv, pp. 1276, 8vo.—This Oriental Flora, as is well known, covers the ground from Greece to Egypt, and to the boundaries of India and of Asiatic Russia. This fourth volume, completed early in 1879 by the publication of the second fasciculus (of almost a thousand pages), contains the *Corolliflorœ* and the *Monochlamydeæ*, in other terms the Gamopetalous and Apetalous Exogens. We may therefore expect that

the indefatigable author will ere long complete this laborious and noble work. These fifteen or twenty years will then be distinguished by the production of the *Flora Australiensis* and the *Flora Orientalis.* Would that the Flora of North America were added to the number. A. G.

4. *Sulla Diffusione dei Liquide Colorati nei Fiori;* by Professor P. A. SACCARDO.—The writer gives an account of his experiments in immersing cuttings of flowering plants in different coloring fluids, and concludes by saying that aniline-green is especially favorable for staining not only the vessels but the parenchyma of flowers. The paper is followed by a sheet on which actual specimens of stained petals serve as illustrations, with a pleasing effect. W. G. F.

5. *Neue Beobachtungen über Zellbildung und Zelltheilung;* by Professor ED. STRASBURGER.—Nos. 17 and 18 of the Botanische Zeitung contain an important article by Strasburger. It had generally been admitted by botanists, including Strasburger himself, that the endosperm was formed in the embryo-sack by free-cell formation. Strasburger now says that this is not true, and that there is no formation of free nuclei in the embryo-sack; he having in previous papers shown that the embryonal vesicle and antipodes do not arise by a free-cell formation. As in the case of the two last named structures, the endosperm-cells are formed by a division of the nucleus of the embryo-sack. *Myosurus minimus* is especially adapted for the study of the subject, owing to the elongated receptacle. Strasburger also states that in the *Ascomycetes* the spore-formation is not preceded by a dissolving of the nucleus of the ascus followed by the formation of free nuclei, but that the original nucleus divides to form the nucleus of each spore. He makes the sweeping assertion that a free formation of nuclei as the initial stage of cell-formation cannot be assumed (in plants), unless we conceive such to be the case in the mother cells of the spores in *Anthoceros* and in those of the macrospores of *Isoëtes*, in which cases observation is obscured by the presence of granular accumulations in the cells. He does not deny, however, that free nuclei may be formed in some instances, but only that it does not accompany cell-formation. In *Spirogyra*, for instance, the spore has at first no nucleus but one is formed at the time of germination. The same is true of the swarm-spores of *Ulothrix*.

The last part of the paper treats of the different arrangements of nuclear plates and nuclear threads, as a comprehensive distinction between the division of animal and vegetable cells in the formation of what Strasburger calls the cell-plate in plants. This is dependent upon the presence of a cellulose membrane in plants. It may be objected, however, that no cellulose membrane can be detected in many plant-cells. W. G. F.

6. ARNOLD ARBORETUM.—*Prof. Charles S. Sargent* is appointed Professor of Arboriculture in Harvard University, along with the directorship of the Arnold Arboretum at the Bussey Institution. He now devotes himself entirely to the arboretum, resigning the

charge of the Botanic Garden at Cambridge, which is assumed by Professor Goodale.

7. Prof. J. G. AGARDH has resigned the chair of Botany at the University of Lund. *Dr. F. W. C. Areschoug* has been appointed his successor.

8. P. VAN TIEGHEM is appointed Professor of Vegetable Anatomy and Physiology at the Jardin des Plants, Paris, in the chair vacated by the death of Brongniart some years ago.

9. Dr. ODOARDO BECCARI succeeds to the late Prof. Parlatore as Professor of Botany and Director of the Gardens at Florence.

10. *Die Spongien des Meerbusen von Mexico*, von OSCAR SCHMIDT. 4to, 1st Heft, with four plates. Jena, 1879.—This memoir relates to sponges collected by the dredging expedition of the steamer Blake, under the supervision of Alexander Agassiz. The excellent plates illustrate the forms and spicula of many species.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Catalogue of Scientific Serials*, from 1633 to 1876, by SAMUEL H. SCUDDER. 358 pp. 8vo. Cambridge, Library of Harvard University, 1879.—This catalogue embraces the Transactions and Bulletins or Proceedings of Learned Societies in the Natural, Physical and Mathematical sciences of all countries, as well as independent journals. It has been prepared, under the auspices of the Harvard College Library, by Mr. Scudder, assistant Librarian; and it is a result of a vast amount of labor and great care. All persons interested in the progress of science will find it an invaluable companion. The titles are arranged alphabetically under the heads of each of the States or Countries from which they were issued, and, in addition, there are Indexes of titles and of places of publication. Harvard Library has met the expense of publication, with the expectation that the demand for the volume will refund the outlay, and with the promise that if so far remunerated, this shall be the beginning of a series of "works such as may be properly undertaken by a public Library, and do not offer inducement for commercial speculation;" and it will be greatly for the benefit of learning in the land, that in this there should be no disappointment.

2. *A Sketch of Dickinson College*, Carlisle, Pennsylvania; by CHARLES F. HIMES, Ph.D., Professor of Natural Science. 156 pp. 12mo, illustrated by engravings, and by photographs executed in the Laboratory. Harrisburg, 1879.—*The History of Dickinson College*, has a general interest because of the connection with its scientific department, the second year after its establishment, in 1811, of Thomas Cooper, the friend, and companion over the sea, of Priestley—a man of wide range of learning, of great chemical knowledge for his time, and of strong opinions on all subjects. Prof. Himes's "Sketch," contains, among its photographic plates, one with figures of the air-gun and burning glass which, along

with a telescope, Dr. Cooper purchased of Priestley for the college, by authority of its Board of Trustees, and which are now among its physical apparatus. It appears further from the sketch that it was while in this position that Dr. Cooper revived the "Emporium of Arts and Sciences," one of the earliest of American Scientific Journals, and gave it "a high scientific character," and issued also an edition of Accum's Chemistry in two volumes. Thus the scientific department of Dickinson was one of the earliest established in the country, and behind no other in the learning and ability of its chief instructor. The Journal, a bi-monthly of 150 pages, came to an end in 1814—the long delay of the final volume being explained by the fact of "the printers serving their country as volunteers." Dr. Cooper left his chair in 1815, and became afterward President of South Carolina College. Prof. Baird, a graduate of Dickinson College, now Secretary of the Smithsonian Institution, was made its Professor of Natural History in 1848, and held the office until 1850, when his connection with the Smithsonian Institution began under Professor Henry.

3. *Ephemeris of the Satellites of Mars for October and November*, 1879.—The ephemeris on pages 317, 318 of this volume, was prepared for the Journal by Henry S. Pritchett, Assistant Astronomer in the United States Naval Observatory at Washington.

4. *Scientific Lectures;* by Sir JOHN LUBBOCK, Bart., Vice President of the Royal Society, etc. 188 pp. 8vo. London, 1879. (Macmillan & Co.).—This volume contains six lectures by Sir John Lubbock: on Flowers and Insects, on Plants and Insects, on the Habits of Ants, Introduction to the Study of Prehistoric Archæology, and an Address to the Wiltshire Archæological and Natural History Society. They are in part the result of original research; and although, as the Preface says, "the little book does not contain anything new to those who have specially studied the parts of science with which it deals," many of the facts are among the most remarkable in science, and make instructive and attractive reading for all inquiring minds. Further, they are well calculated to cultivate an inquiring spirit in the mind of those who have thought themselves indifferent to the study of nature.

5. *Shell Mounds of Omori*, by EDWARD S. MORSE, Prof. Zool. Univ. Tokio, Japan. Mem. Univ. Tokio, vol. i, part 1, 1879. 36 pp. large 8vo, with 18 plates.—Professor Morse gives evidence that the mound-builders were cannibals either from an emergency or by preference. The implements obtained are made of stone, horn, bone and pottery, but there are no arrow-heads or spear-points of flint or other material, and few of the relics are of stone.

Report of Work of the Agricultural Experiment Station, Middletown, Conn., 1877–8. 174 pp. 8vo. Hartford, 1879.

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ART. L.—*On Photographing the Spectra of the Stars and Planets;*
by HENRY DRAPER, M.D.

[Read before the National Academy of Sciences, Oct. 28th, 1879.]

FOR many years it has seemed probable that great interest would be attached to photographs of the spectra of the heavenly bodies, because they offer to us conditions of temperature and pressure that cannot be attained by any means known at present, on the earth. The especial point of interest is connected with considerations regarding the probable non-elementary nature of the so-called elementary bodies. There has long been a suspicion in the minds of scientific men that one or more truly elementary bodies would be found from which those substances which have not as yet been decomposed, are formed. The recent publications of Lockyer have attracted particular attention to this topic.

The most promising laboratory processes for accomplishing the dissociation of our present elements depend upon the action of heat, especially when accompanied by electrical influences, and upon relief of pressure. But the temperature we can employ is far below that found in the stars, which is comparable only with the heat of our Sun, and when in addition the application of heat is restricted by the narrow range of circumstances under which we can also reduce the pressure, complete success seems to be impracticable in the laboratory.

But in the stars, nebulæ and comets there is a multitude of experiments all ready performed for us with a variety of conditions of just the kind we need. It remains for us to observe and interpret these results, and this is the direction I have sought to pursue.

There is but one mode of investigation that can add materially to the knowledge Astronomy has given us of the heavenly bodies; that is the spectroscopic. This in its turn is capable of a subdivision into two methods, one by the eye, the other by photography. Each of these has its special advantages and each its defects. The eye sees most easily the middle regions of the spectrum, and can appreciate exceedingly faint spectra; by the aid of micrometers it can map with precision the position of the Fraunhofer lines, and by estimation it can with tolerable accuracy approximate to the relative strength, breadth and character of these lines. The character of the spectrum lines is however of great value for the purposes we are now speaking of, and the greatest precision is needed. Photography, on the other hand, as applied to faint spectra, deals mainly with the more refrangible region, and cannot at present be employed in stellar work below the line F. Fortunately there is no break in the spectrum between the place where the eye leaves off and photography begins, and hence the two methods lend one another mutual assistance. The photograph when suitably accommodated with a standard reference spectrum from some known source, gives valuable indications as to the positions and all the peculiarities of the lines.

But the application of photography to the taking of stellar spectra is surrounded by obstacles. These are partly due to the small quantity of light to be dealt with, and partly to the fact that it is necessary to overcome the motion of the earth and other causes, such as atmospheric refraction, which seem to make a star change its place continually. The exposures of the sensitive plate require to be sometimes for two hours, even with a large telescope, and if during that time the image of the star at the focus of the telescope has changed place $\frac{1}{500}$ of an inch the light no longer falls on the slit of the spectroscope. The changes of the earth's atmosphere in regard to photographic transparency as well as by fog also offer impediments, and promote the chances of failure. There is often a yellow condition of the air, which may increase the length of exposure required forty times or more.

It will, from what has been said above, be readily perceived that a research such as this consumes a great deal of time, in fact these experiments and the preparations for them have extended over more than twelve years. A large telescope is required, and for many reasons the reflector at first seems most suitable. Recently, however, I have found that the refractor has also some special advantages.

In 1866 I had already constructed a silvered glass reflector of 15½ inches aperture, which was commenced in 1858, and had taken with it many hundreds of photographs of the Moon. But as the mounting had been contrived for lunar photography and to avoid the Moon's motion in declination, the instrument was not suitable for the spectroscopic work contemplated. A reflector of twenty-eight inches aperture was therefore commenced in 1866, and in 1871 it was ready for use.

On May 29th, 1872, my first photograph of the spectrum of a star was taken, the spectrum of Vega being photographed by the aid of a quartz prism. At this time I did not happen to know that Dr. Huggins, who is so distinguished for his thorough and accurate researches on the visible portion of the spectra of the heavenly bodies, had already made some attempts in this direction, as is shown by the following paragraph from the Transactions of the Royal Society for 1864: "On the 27th of February, 1863, and on the 3d of March of the same year, when the spectrum of Sirius was caused to fall upon a sensitive collodion surface an intense spectrum of the more refrangible part was obtained. From want of accurate adjustment of the focus, or from the motion of the star not being exactly compensated by the clock movement, or from atmospheric tremors, the spectrum, though tolerably defined at the edges, presented no indications of lines. Our other investigations have hitherto prevented us from continuing these experiments farther; but we have not abandoned our intention of pursuing them."

During August, 1872, I took several photographs of the spectrum of Vega, and these showed four strong lines at the more refrangible end of the spectrum, the least refrangible being near G. On pursuing the subject and seeking to ascertain what substances gave rise to these lines, it became obvious that a photographic study of this part of the spectrum for the metals and non-metals was necessary to interpret the results. This of course opened out a large field for experiment, requiring many years for its study, and hence, as several physicists were engaging in the study of the spectra of the metals, I concluded to discontinue the experiments commenced in 1870 on the spectra of the metals and to confine the investigation mainly to the non-metals. The initial step was, however, to obtain a fine photograph of the normal solar spectrum, so that the wave lengths of the lines up to O [wave length 3440] might be determined with precision.

In the spring of 1873 I published a paper on the diffraction spectrum of the Sun, illustrated by a photograph embracing the region from wave length 4350 near G to 3440 near O, and in the fall of the same year took photographs of the spectra of several non-metals, notably nitrogen, carbon, and oxygen.

The experiments were interrupted, in the spring of 1874, by going to Washington to superintend the photographic preparations for the United States observations on the Transit of Venus.

Since that time my experiments have been divided into two parts, an astronomical portion occupying principally the summer season, and a laboratory portion during the rest of the year. The former consisted of photographs and observations on the spectra of the stars, planets and sun; the latter of photographic work on the spectra of the elements and particularly the non-metals, and has led to the discovery of oxygen in the sun.

In 1876, Dr. Huggins published a note in the Proceedings of the Royal Society, accompanied by a wood-cut of the spectrum of Vega, with a comparison solar spectrum. Seven lines were observed in the spectrum of Vega. In the summer and autumn of 1876 I made several photographs of the spectra of Vega, *α* Aquilæ and Venus, and sent a note concerning them to this Journal.

Since that time Dr. Huggins has pursued the subject actively in spite of the London atmosphere, and has attained very fine results, which I had the pleasure of seeing at his observatory last spring. These he is preparing to publish shortly. In my observatory photographs have been taken of the spectrum of Vega, Arcturus, Capella, *α* Aquilæ, Jupiter, Mars, Venus, the Moon, etc. Recently the plan has been to have a comparison solar spectrum on every plate, derived either from the diffused light of our atmosphere or from the Moon or from Jupiter. In this way no difficulty in determining the wave lengths of the lines is encountered, and the changes produced by our atmosphere are eliminated. The telescope and spectroscope are now in good working order, but to secure the requisite degree of precision of movement it has been necessary to make seven different driving clocks before a satisfactory one was attained.

It has been remarked that on account of the faintness of the light of stellar spectra, prolonged exposures of the sensitive plate are required. In former times when the dry processes of photography were much less sensitive than the best wet plates, the exposure was limited by the length of time the plate could be left in the camera without being stained by drying. But now, since the gelatino-bromide process has been introduced, this obstacle has been removed and a sensitive plate is sometimes exposed two hours to the spectrum of a star and then almost an hour to Jupiter for the comparison spectrum. The best, and most sensitive, gelatine plates I have used are those made by Wratten & Wainwright of London; Dr. Huggins was good enough to call my attention to them.

It is not worth while to describe the various forms of spectroscope that have been employed in the last ten years, quartz, Iceland spar, hollow prisms and flint glass have been the materials, and they have been sometimes direct vision and sometimes on the usual angular plan. Gratings on glass and speculum metal given to me by Mr. Rutherfurd have been tried. The length of spectroscope has been sometimes twenty-eight feet and sometimes not as many inches.

The especial spectroscope for stellar work that is now on the telescope is intended to satisfy the following conditions: 1st, to get the greatest practicable dispersion with the least width of spectrum that will permit the lines to be seen; 2nd, to use the entire beam of light collected by the 28-inch reflector or 12-inch achromatic without loss by diaphragms; 3d, to permit the slit to be easily seen so that the star may be adjusted on it; 4th, to avoid flexure or other causes that might change the position of the spectrum on the sensitive plate in pointing the telescope first on one and then on another object; 5th, to admit of observing the spectrum on the sensitive plate at any time during an exposure without risk of shifting or disarrangement. The dispersion is produced by two heavy flint prisms which are devoid of yellow color; the telescopes are about six inches in focal length and the slit has a movable plate in front of it, enabling the operator to uncover either the upper or the lower portion at will.

During the past summer this spectroscope has been used with the Clark refractor of 12 inches aperture, partly because the 28-inch reflector has been kept unsilvered since it was used in taking photographs of the Transit of Mercury, on account of its employment in certain experiments on the Sun. Moreover, there is an advantage possessed by the refractor for this work which does not appear at first sight. Naturally one supposes that a reflector which brings all the rays from the star, no matter what their refrangibility, to a focus in one plane, would be best, because when the slit is put in that plane it is equally illuminated by rays of all refrangibilities, and the spectrum will be parallel-sided in its whole length. On the other hand a refractor is not achromatic, for the violet end of the spectrum comes to a focus either inside or outside of the plane of the rays in the middle of the spectrum, and in observing the spectrum it is not parallel-sided. This peculiarity was used by Mr. Rutherfurd to enable him to correct a telescope lens for the ultra violet rays. It is easy therefore with a refractor so to adjust the position of the slit that you may have a spectrum tolerably wide at F and G, and which gradually diminishes in width toward H, and finally becomes almost linear at M. Now as the effect of atmospheric absorption on the spectrum increases as you pass from G toward H and above H, by diminishing the width of the spectrum you can in some measure neutralize the effect, and at one exposure obtain a photograph of nearly uniform intensity from end to end, though it is of variable width. If it were not for this it would be necessary to have the spectrum over-exposed at G in order to be visible above H, or else to resort to an elaborate diaphragming which is difficult.

It is my intention next season to return to the use of the 28-inch reflector, because it collects nearly five times as much light as the 12-inch does, after making allowance for the secondary mirror. Of course in a large reflector the difficulties of flexure and instability of the optical axis are much increased, and keeping a star on the slit will be troublesome, especially as the magnifying power on the image is about 50.

As to the results obtained, it has already been mentioned that the spectra of several stars and planets have been photographed. The subject of planetary spectra will be reserved for a future communication. A preliminary examination at once shows that these stellar spectra are divisible into two groups: first, those closely resembling the solar spectrum, and second, those in which there are relatively but few lines, and these of great breadth and intensity. The photographs of the spectra of Arcturus and Capella are so similar to the solar spectrum, that I have not up to the present detected any material differences. But on the other hand, the spectra of Vega and *a* Aquilæ are totally different, and it is not easy without prolonged study and the assistance of laboratory experiments to interpret the results, and even then it will be necessary to speak with diffidence. I have not as yet obtained any stellar spectrum photographs belonging to the third and fourth groups of stellar spectra as described by Secchi. These, if obtainable, will aid materially in discussing the whole subject, but unless a star passes near the zenith it is hard to make a fair study of its spectrum by photography, because atmospheric absorption in the ultra violet region increases rapidly as the altitude decreases. In the case of the Sun, I have found that at sunset the exposure necessary to photograph the spectrum above H, is often 200 times as long as at midday.

In the case of the spectrum of Vega when examined by the eye, the lines C, F, near G and *h*, are readily visible, but lines such as D and *b* are relatively faint. It is clear then, that hydrogen exists to a large extent in the atmosphere of that star. But on examining the photograph of its spectrum it is evident that other lines just as conspicuous as the hydrogen lines, are present. One of these corresponds in position and character to H_1 and seems to coincide with a calcium line. It appears to me, however, that the evidence of this coincidence is not complete.

In attempting to reason from these photographs as the matter now stands, it is necessary to try at every step farther experiments in order to find out whether the facts agree with hypothesis, and it is this very condition of affairs that gives hopes of results valuable in their bearing on terrestrial chemistry and physics. In the photographs of the spectrum of Vega there are eleven lines, only two of which are certainly accounted for, two more may be calcium, the remaining seven, though bearing a most suspicious resemblance to the hydrogen lines in their general characters, are as yet not identified. It would be worth while to subject hydrogen to a more intense incandescence than any yet attained, to see whether in photographs of its spectrum under those circumstances any trace of these lines, which extend to wave length 3700, could be found.

It is to be hoped that before long we may be able to investigate photographically the spectra of the gaseous nebulæ, for in them the most elementary condition of matter and the simplest spectra are doubtless found.

ART. LI.—*Abstract of Observations upon the Artificial Fertilization of Oyster Eggs, and on the Embryology of the American Oyster;* by W. K. BROOKS, Associate in Biology, Johns Hopkins University. (Notes from the Biological Laboratory of the Johns Hopkins University).

ALL the writers upon the development of the oyster, from Home (Phil. Trans., 1827), to Möbius (Austern und Austernwirtschaft, 1877), state that the eggs are fertilized inside the shell of the parent, and that the young are carried inside the mantle cavity until they are provided with shells of their own: that they leave the parent in a somewhat advanced state of development, and that their free-swimming life is of short duration and lasts only until they find a suitable place to attach themselves.

Misled by these statements, which do not apply to our species, I opened a number of oysters during the summer of 1878, and examined the gills and the contents of the mantle-chambers for young, but found none, and concluded that the time during which the young are carried by the parent must be so short that I had missed it. I undertook the same investigation this May, with the determination to examine adult oysters for young every day during the breeding season, and at the same time to try to raise young for myself by the artificial fertilization of eggs taken from the ovaries. I had complete success with the second method from the first, and succeeded in raising countless millions of young oysters, and in tracing them through all their stages of development up to the time when they had acquired all the characteristics which Salensky, Lacaze Duthiers, Möbius and others have figured and described in the young European oyster at the time it leaves its parent. I also made careful examination of the gills and mantles of more than a thousand oysters, but never found a single fertilized egg or embryo inside the mantle-cavity of an adult, although I found females with the ovaries full of ripe eggs, others with the ovaries half empty, others with them almost entirely empty, and others at all the intermediate stages, and I therefore feel sure that my examinations were made upon spawning oysters.

While this evidence is for only one season and one bed, I think that until it is shown to be exceptional, we must conclude that there is an important difference in the breeding habits of American and European oysters, and that the eggs of the American oyster are fertilized outside the body of the parent; that during the period which the European oyster passes inside the mantle-cavity of the parent, the young American oyster swims at large in the open ocean.

The more important points in the development of the oyster are:

1. The oyster is practically unisexual, since at the breeding season each individual contains either eggs or spermatozoa exclusively.

2. Segmentation takes place very rapidly and follows substantially the course described for other Lamellibranchs by Lovén and Flemming.

3. Segmentation is completed in about two hours, and gives rise to a gastrula, with ectoderm, endoderm, digestive cavity and blastopore, and a circlet of cilia or velum. At this stage of development the embryos crowd to the surface of the water and form a dense layer less than a quarter of an inch thick.

4. The blastopore closes up; the endoderm separates entirely from the ectoderm, and the two valves of the shell are formed, separate from each other, at the edges of the furrow formed by the closure of the blastopore.

5. The digestive cavity enlarges, and becomes ciliated, and the mouth pushes in as an invagination of the ectoderm at a point directly opposite that which the blastopore had occupied. The anus makes its appearance close to the mouth.

6. The embryos scatter to various depths, and swim by the action of the cilia of the velum. The shells grow down over the digestive tract and velum, and the embryo assumes a form so similar to various marine lamellibranch embryos which are

captured by the dip net at the surface of the ocean that it is not possible to identify them as oysters without tracing them from the egg. The oldest ones which I succeeded in raising in aquaria were almost exactly like the embryos of Cardium, figured by Lovén.

7. The ovaries of oysters less than 1½ inches in length, and probably not more than one year old, were fertilized with semen from males of the same size, and developed normally.

An illustrated paper on the embryology of the oyster, with a detailed account of my observations, will be published, shortly, in the Report of the Maryland Fish Commission for 1879.

Baltimore, Nov. 5, 1879.

ART. LII.—*Origin of the Lœss;* by G. C. BROADHEAD.

WHAT facts Baron von Richthofen may have observed in Eastern Asia tending to form his opinion of the origin of the lœss I have not had the opportunity to examine; but from careful observations of the lœss in many places along and adjacent to the Missouri and Mississippi rivers, I cannot refer these deposits to æolian or wind-drift agency. Professor Hilgard, in his article in this Journal for August, conveys to us some interesting and correct testimony.

That the lœss is stratified in many places I can bear testimony; a notable example may be seen in the bluffs at St. Charles, Mo., near the railroad depot, where it shows finely laminated deposits, made up of planes of differently colored clays and sands, the latter very finely comminuted, showing that at this place the sediment was deposited at different times from very quiet waters. The beds of sand also sometimes appear evidently as if deposited from water. Calcareous concretions are quite characteristic of the lœss. They are generally of roundish form, but often elongated, and can sometimes be traced for several hundred feet horizontally, forming beds from a few inches to more than a foot in thickness. The concretions are either united to each other or often separated.

Land snails are occasionally found. Some of the sands are ferruginous, and pipe-stem forms of iron sand are occasionally found, with also hollow root-like forms of calcareous matter. The cohesive strength of the particles tends to preserve the mass in a vertical position for a long time, even at sixty to seventy feet height. When not quite as cohesive, time will wear off the rougher points, and produce rounded mammillated hills covered with a thin soil, and sloping at about an angle of 50°; for example, the "Mamelles" below St. Charles, and the hills at Glasgow and St. Joseph. Our richest upland soils near the Missouri river are due to a subsoil of lœss.

Lastly, the æolian hypothesis is untenable when referred to the lœss of the valleys, hillsides, and hills adjacent to the Missouri and Mississippi rivers; for, although often of a depth from twenty to two hundred feet, it cannot be clearly traced far back from these rivers, and I believe in Missouri not farther than fifteen miles from them. It must therefore have been a sediment in the quiet waters when the rivers were blocked up below by ice; when the barrier melted away a channel was worn through the silt, leaving these finely comminuted clays on the neighboring hills as we now find them.

The waters of the Missouri river are full of very minute particles held in suspension. Its waters appear to be whirling continually, the channel is daily changing, sands are deposited on the bars, and fine silt at quiet eddies or in the mouths of the small tributaries, and the latter closely resembles the lœss of the neighboring hills. The most if not all of these clays may have originated from the Tertiary and Cretaceous beds of the Upper Missouri.

ART. LIII.—*Observations on the planets Hersilia and Dido;* by Professor C. H. F. PETERS. (From a letter to the Editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., November 8, 1879.)

IN the month of October, two planets were added by me to the group between Mars and Jupiter. I take pleasure in communicating the following observations on their positions. The dates of discovery were respectively Oct. 13 and Oct. 22.

(206) *Hersilia.*

1879.	Ham. Coll. m. t.	App. α.	App. δ.	No. of comp.
Oct. 13.	14^h 35^m 52^s	1^h 0^m 36^s·63	+ 1° 24′ 52″·2	15
Oct. 14.	10 43 25	0 59 56·51	+ 1 19 54·1	10
Oct. 16.	9 51 24	0 58 23·52	+ 1 9 10·6	9
Oct. 20.	9 46 52	0 55 17·26	+ 0 48 11·1	10

(209) *Dido.*

1879.	Ham. Coll. m. t.	App. α.	App. δ.	No. of comp.
Oct. 22.	14^h —^{m} —^{s}	1^h 23^m 49^s	+13° 23·1	—
Oct. 25.	11 12 36	1 21 32·94	+13 14 27·4	10
Oct. 26.	10 49 55	1 20 47·08	+13 11 20·4	10
Nov. 7.	12 1 6	1 12 12·93	+12 33 1·1	4

The magnitude of Hersilia was 11th; that of Dido about 12th.

ART. LIV.—*On Triple Objectives with complete Color Correction;* by CHARLES S. HASTINGS.

THE prime defect in the large refractors of the present day is the secondary spectrum. This, arising from the irrationality in the spectra produced by the crown and flint glass, hardly noticeable in small apertures, detrimental in telescopes of medium power, is positively obnoxious in the large instruments and will speedily put an end to farther increase in dimensions. On this account there have been many efforts to produce two kinds of glass differing sufficiently in dispersive power, which would still yield mutually rational spectra. As far as I know we are now no nearer success in this direction than when Brewster investigated the subject fifty years ago.

Can we secure the same end by increasing the number of glasses in the objective? Theoretically, since a new disposable constant for color change is introduced with each lens in the system, the answer is evidently affirmative; but if we limit ourselves by the condition that the construction shall be practicable, i. e., that there shall not be too many lenses and the curvatures shall be moderate, the conclusion is not so ready. On entering the discussion we will assume three as the limiting number of lenses and $\frac{1}{15}$ the focal length as the minimum radius of curvature.

The formula for the focal length F of three thin lenses in contact is, if we set $\varphi=\frac{1}{\mathrm{F}}$:

$$\varphi=(n'-1)\left(\frac{1}{r_1}+\frac{1}{r_2}\right)+(n''-1)\left(\frac{1}{r_3}+\frac{1}{r_4}\right)+(n'''-1)\left(\frac{1}{r_5}+\frac{1}{r_6}\right),$$

where n', n'', n''' are the indices of refraction for the three materials used, and r_1, r_2, ... r_6, are the radii of curvature for the six surfaces successively. We may write this more concisely for our end, as follows:

$$\varphi=(n'-1)\mathrm{A}+(n''-1)\mathrm{B}+(n'''-1)\mathrm{C},$$

calling A, B and C the *curvature sums* of the first, second and third lens respectively.

The problem then, succinctly stated, is to find values of A, B and C, no one of which shall be more than thirty when $\varphi=1$ and which shall make φ independent of the wave length of light transmitted.

If n can be expressed as a function of any variable x of the form:

$$n=A+Bf_0(x)+\Gamma f_1(x)$$

the problem has its mathematical expression in the equations:

$$\varphi_\lambda=(n_\lambda'-1)A+(n_\lambda''-1)B+(n_\lambda'''-1)C=1$$

$$\frac{d\varphi}{dx}=(B'f_0'(x)+\Gamma'f_1'(x))A+(B''f_0'(x)+\Gamma''f_1'(x))B+(B'''f_0'(x)+\Gamma'''f_1'(x))C=0;$$

but since the latter must hold true for all values of the variable x the final conditions for perfect color correction are:

$$\left.\begin{array}{r}(n_\lambda'-1)A+(n_\lambda''-1)B+(n_\lambda'''-1)C=1\\ B'A+B''B+B'''C=0\\ \Gamma'A+\Gamma''C+\Gamma'''C=0\end{array}\right\}\qquad(2)$$

the only practical limitation being that neither A, B or C surpass thirty as a maximum.

As to the choice of the variable x, the most natural suggestion is the wave length of light, using the first three terms of Cauchy's well-known formula as an expression for n; but there are two objections to such a course, the first and most important being that three terms of this series will not express the values within the necessary limits of accuracy, and the other lies in the great labor requisite to compute the constants. I have, therefore, chosen to take the value of n for some one material as a standard and compute by the method of least squares the values for other materials as functions of this. The standard selected is Feil's Crown Glass, No. 1219, which I have studied and described, with four other kinds, on page 273 vol. xv, of this Journal. The reason determining the choice is the greater accuracy of our knowledge of its constants over that of any other light glass. The form of the function is a trinomial of the second degree, thus:

$$N=A+Bn+\Gamma n^2 \qquad (3)$$

Doubtless by not restricting it to the first and second powers of n a formula might be shaped which would make the differences between the observed and calculated values less, but as that could be attained only at the expense of much greater labor in determining the various values of the constants, and moreover, as the errors of observation are generally greater than those of the formula, it seems unadvisable to modify it.

In this discussion I have included all the different varieties of glass the optical constants of which I have been able to find given with the requisite accuracy. Unfortunately there are but few. Besides the five which I have determined and are cited above, viz:

Feil's Crown 1219,	α
" Flint 1237,	β
" Flint 1241,	γ
—— Crown A,	δ
—— Flint B,	ε

are included the seven of Fraunhofer,[*] viz:

Crown 13,	ζ
Crown 9,	η
Crown M,	ϑ
Flint 13,	ν
Flint 3,	κ
Flint 30,	λ
Flint 23,	μ

six of Van der Willigen[†] (one closely resembles my A above, while two others are almost exactly alike), viz:

Crown, Merz No. III,	ν
Crown, Merz No. IV,	ξ
Flint, Steinheil No. II,	ο
Flint, Merz No. V,	π
Flint, Hoffmann No. I,	ρ
Flint, Merz. No II,	σ

and finally one of Ditscheiner,[‡]

Flint, ———,	τ

There are further measurements of 18 different prisms by Dutiron,[§] but so inaccurate as to be worthless for our purpose.

In the order in which the glasses are named are entered in table I, the values of the constants for (3).

TABLE I.

	A.	*B.*	*Γ.*
α	+ 0·	+ 1·	+ 0·
β	22·3186075	−29·1759937	10·2399102
γ	14·0097123	−17·9513549	6·4320057
δ	·5679958	+ ·2172063	·2681091
ε	21·026827	−27·430617	9·645678
ζ	·5749543	+ ·2333290	·259890
η	·9025943	− ·2110704	·411148
ϑ	5·2924649	− 6·1318968	2·4193199
ι	19·6074744	−25·7440377	9·1597811
κ	20·7768050	−27·0625275	9·5093547
λ	24·6152640	−32·2820439	11·2916241
μ	25·4950932	−33·4611946	11·688423
ν	2·250818	− 1·973145	0·983738
ξ	2·737385	− 2·679993	1·241673
ο	19·541685	−25·438209	8·976709
π	27·444400	−36·035067	12·537277
ρ	43·623628	−57·822556	19·899438
σ	69·141334	−91·827575	31·313410
τ	19·960275	−26·041640	9·196286

[*] Schumacher's Astronomische Abhandlung für 1823.

[†] Archives du Musée Teyler.

[‡] Sitzungsberichete der k. k Akad. d. Wissenschaften in Wien. Oct., 1864.

[§] Comptes Rendus, xxix, pp. 632–636. Poggend. Annal., lxxix, pp. 335–336. Annales de Chimie, xxviii, pp. 176–210. These incredible values, which are extensively quoted in prominent text books on optics, have given me a deal of trouble, used as they are in several places to discuss the defects and possible improvement of the double objective. Only by the merest chance I found on the last leaf of the Annales de Chimie, xxviii, pp. 501, 502, a set of corrections to *all* the values. These new values are less fantastic, but still the errors are large and even indicated anomalous dispersion is not wanting.

If we tabulate the differences between the observed values and those derived by substitution in the formula, we have the following expressed in units of the sixth place:

TABLE II.

$n-N$.

	A	B	C	D	λ 5614	E	F	λ 4548	G	h	H
α	0	0	0	0	0	0	0	0	0	0	0
β	+26	− 4	−12	−31	− 6	+ 3	+23	+ 4	+12	− 4	−10
γ	+24	−10	−10	−21	− 4	+ 6	+19	+ 4	+ 4	− 1	− 7
δ	− 9	− 0	+ 2	− 1	+15	+15	−14	—	−20	0	+12
ε	+ 8	− 8	− 3	−10	+ 4	+13	+ 5	—	−10	− 9	+12
ζ	—	+ 2	+ 4	− 1	—	+ 4	−11	—	− 4	—	+ 3
η	—	−15	+ 4	+16	—	− 3	+17	—	−34	—	+16
ϑ	—	+ 4	+ 8	−25	—	+10	+ 6	—	− 2	—	− 1
ι	—	− 2	− 7	−21	—	+36	+15	—	−24	—	+ 2
κ	—	−42	+29	+35	—	−11	−20	—	+ 5	—	+ 2
λ	—	− 1	+45	−27	—	+ 7	− 7	—	+19	—	−36
μ	—	+19	+10	−34	—	−30	+24	—	+30	—	−19
ν	+23	+19	−22	−42	—	+14	+20	—	+13	+19	
ξ	+21	− 3	−16	−15	—	+15	+11	—	−10	+22	
o	+38	−27	−13	−25	—	+ 2	+28	—	+15	−19	
π	+54	−16	−37	−34	—	− 9	+28	—	+29	+17	
ρ	+40	−19	−30	−19	—	+11	+25	—	+ 4	−11	
σ	−60	−47	−26	+25	—	+119	+116	—	−32	−92	
τ		− 8	+26	−10	−34	− 0	+43	—	+ 8	−26	

The systematic distribution of the differences in the first group shows, not only the short-coming of the formula, but also that the extreme accuracy, indicated by the probable errors attached to the indices, is not imaginary.

The accuracy of the second group is also great but much inferior to the first. Occasional abrupt changes as in that of ιD to ιE in table II can only arise from erroneous values in the indices. Here we recognize at once that n_{ι} must be about thirty too great.

The indices of the following groups are only given to five places of decimals and are evidently made with much less care than the others.

By taking from table I the constants for any three glasses and substituting them in formulas (2), we obtain values of A, B and C, which would give complete color correction, but in general the values would not be all below thirty, the limiting maximum. Of those, however, which satisfy this condition, I select four cases, confining myself to these four, not because it exhausts all the serviceable combinations or even gives the smallest values for the curvature sums, but because it introduces eight out of the nineteen glasses which are most useful. They are:

Case I.	α	β	ι
" II.	ν	π	o
" III.	ν	π	τ
" IV.	ξ	π	o

giving values for the curvature sums:

	A.	B.	C.
I.	3·47026	7·20807	— 8·35472
II.	9·47513	14·28004	—21·23665
III.	7·58585	11·57425	—16·59076
IV.	11·67459	18·10299	—27·22301.

Substituting these values in the general formula (1) we derive for F the following, the first column giving the Fraunhofer ray for which the focal length is computed:

Table III.

	I.	II.	III.	IV.
A	———	1·00002	———	1·00000
B	1·00000	·99949	·99989	·99968
C	·99999	1·00043	1·00102	1·00053
D	·99999	1·00026	1·00052	1·00005
E	1·00024	·99992	·99942	·99993
F	·99999	·99988	·99951	·99999
G	·99999	1·00002	1·00030	1·00000

To exhibit more distinctly the improvement in this form over the double objective, I arrange the differences in the above values between each and the true focal length of that system in a table, supplementing it with a sixth column in which are entered the corresponding differences for a double objective of glasses α and β with its best color correction, and having a focal length of unity.

Table IV.

	I.	II.	III.	IV.	V.
A	—	+ 2	—	— 3	+135
B	+ 1	—53	—22	—35	+ 66
C	0	+41	+91	+50	+ 41
D	0	+28	+41	+ 2	+ 0
E	+25	—10	—67	—10	+ 13
F	0	—14	—60	— 4	+ 73
G	0	+ 2	+21	— 3	+287

The large difference in F_E is owing to an erroneous value of n_E in Fraunhofer's Flint 13.

The greater differences in the other cases are to be attributed to inaccurate measurements of the optical constants, inaccuracies which are most marked in Ditscheiner's determinations. It may be noted that only in the first two groups are the indices given to six places of decimals, and whatever the errors may be they are multiplied by large factors in all but the first case. That these differences do not represent any outstanding color we may be sure from their non-systematic character.

The problem is then solved generally and shown to be quite practicable in the case of a number of known varieties of glass.

Of course in its practical application this process should be used to yield a first approximation only, since the thicknesses and distances of the lenses are neglected; but having this there is no difficulty, other than the laborious character of the computations involved, in determining by successive approximations the values of all the radii requisite to secure complete color correction and at the same time eliminate spherical aberration. As in the case of a double objective, after satisfying the conditions of given focal length, of color correction, and elimination of spherical aberration, we have one arbitrary condition to impose, so in a triple objective we have two arbitrary conditions to impose. In my opinion, were we using materials that required large curvature sums, it would be advantageous to utilize these two conditions in making two of the lenses respectively biconvex and biconcave, thus rendering the necessary thickness of the materials a minimum.

These results are directly opposed to those of a recent writer in this Journal.* But his conclusions arise from erroneous calculation. Not only does his interpretation of his equation (12) imply the manifest absurdity that in a system of infinitely thin lenses in contact its properties are determined by the order of the lenses, but the interpretation is impossible. True A_2 should have an opposite sign to A_1+A_3, but that asserts nothing as to likeness of the latter symbols in sign. Thus n in equation (16) may be negative and consequently his subsequent reasoning is fallacious, for in that case n does not have to be infinite to cause equation (27) to vanish. I may add that the origin of the confusion is in making the ratio $\frac{D}{E}$ in equation (9) constant; it may be, and if course should be, indeterminate.

Professor Harkness has made another mistake, founded upon inadequate experiment, which has so important a bearing on the theory of the double objective that it should not be allowed to pass uncorrected. His statement (p. 191) concerning the condition for color correction, is substantially correct, though, in my opinion, it is not self-evident but requires proof. This proof I shall supply in a forthcoming number of the American Journal of Mathematics. His experiment, however, (p. 193) directly contravenes this principle, for he finds that the focal plane does not correspond to the minimum focal distance, but to something greater. The source of error is the introduction of a variable element in the system, namely, the eye, which would adjust itself differently in observing the star and its spectrum. Had the writer used eye-pieces of successively higher power, thus lessening progressively the power of accommodation of the system, with his prism, he would have seen his points γ_m and γ_n approach until they sensibly coincided; or better still, had he formed his spectrum by a grating (such as perforated card-board) before the objective, instead of by a prism between the ocular and eye, he could not have been misled, since the uncolored image would serve to control the eye.

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* Professor Harkness, in the September number, pp. 191–193.

Finally, the fourth conclusion (p. 196) is strictly true, though we are not to conclude, as would seem from the text, that the detriment due to the secondary spectrum depends either solely upon the aperture or varies inversely as the focal length; for, though the secondary spectrum remains constant in dimension with a given aperture and consequently its angular value decreases inversely as the focus, a stellar image (diffraction disk,) increases directly as the focal length. Hence by increasing this element more of the central portion of the secondary spectrum, i. e. the brighter portion, would be absorbed into the stellar disk. In other words, by doubling the length of the telescope the secondary spectrum becomes much less than half as offensive.

Johns Hopkins University, Sept. 20th, 1879.

ART. LV.—*Geology of Virginia:—Balcony Falls. The Blue Ridge and its geological connections. Some theoretical considerations;* by J. L. CAMPBELL, Washington and Lee University.

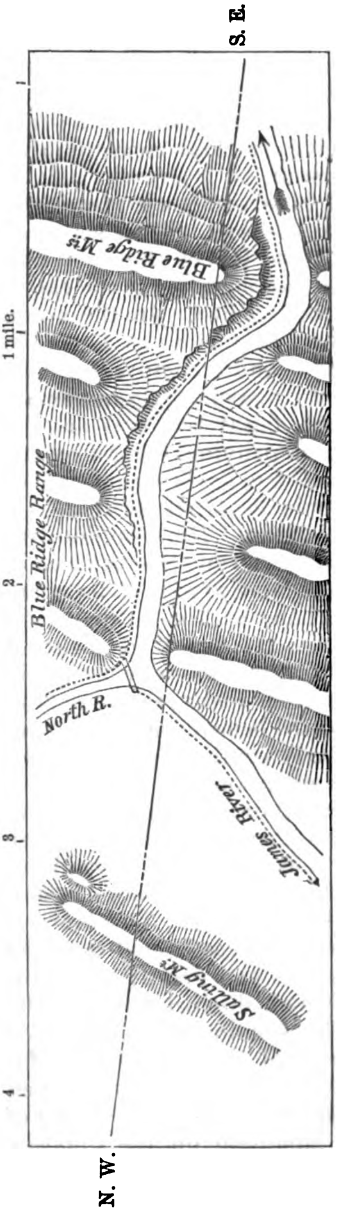
AMONG the many localities in the mountains of Virginia that are peculiarly interesting to the geologist, very few offer attractions superior to those found in the great natural section of the Blue Ridge at Balcony Falls, where the James River passes from the Valley to Piedmont Virginia. The canal from Lynchburg to Lexington passes through this mountain gorge, and renders the exposures of the rocky formations easily accessible. Here both the Archæan and the Primordial formations are displayed in their relative positions, and their contact laid bare to inspection. Reference was made to this point in a former paper (July No. of this Journal, pp. 22, 23), by way of illustration. I now propose to discuss some of its interesting features more in detail.

Topography.—The accompanying map and section will serve to throw light upon both the topographical and the geological features of the locality. Leaving out of view a number of irregular foot-ridges on the southeast side, we may regard the range of mountains here, known as the "Blue Ridge Range," to consist of, (1) the real Blue Ridge on the southeast border—the long water-shed between the valley and Piedmont Counties—between Rockbridge on the northwest and Amherst and Bedford on the southeast. Here and for some miles along its line both ways, this ridge is flanked by Archæan rocks on the southeast and Primordial rocks on the northwest—the latter resting unconformably upon the former. (2) Skirting the northwest side of this leading ridge, and parallel with it, are two well defined lines of broken ridges that have evidently been once continuous, but now consist of short, abruptly terminating mountains, of rounded dome-like hills, and of rugged conical peaks. These all have a frame-work of Primordial sandstones, with the less durable shales of the same period lying along their flanks or filling the depressions between them. Of these lines of ridges the one bordering on the great limestone valley, heretofore described, (see July No.), is by far the most conspicuous, and the most uniform in its physical features. It consists essentially of the durable masses of the Upper Potsdam sandstones, so durable that many parts of it have maintained a height almost equal to that of the main ridge, the average height of which, in this region, somewhat exceeds 2500 feet. The mean bearing of this portion of the range is about N. 35° E.

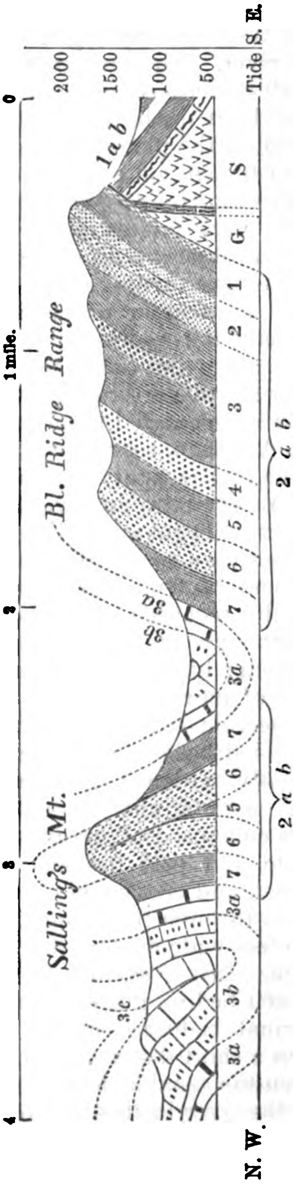
Salling's Mountain, seen on the left of the map, is an outlying ridge of Primordial sandstones and slates, cut off at its northeastern end by the North River, and at its southwestern end by James River. It is separated from the principal chain by a narrow synclinal valley of limestone (Lower Silurian), most of which is concealed from view by an extensive bed of *alluvium*, accumulated by the two rivers that meet here; but accumulated originally in a Y-shaped lake, through which they seem to have flowed at some former period of their history.

The two rivers above mentioned, traverse the little valley obliquely, and meet at a very obtuse angle just where their waters, as one united stream, enter the deep gorge or cañon by which they pass through the mountain range. Just below their junction are mills for grinding hydraulic lime burnt from the ledges that crop out a little higher up the James River. "Balcony Falls" is the name given to a succession of "rapids," beginning about half-a-mile below the Cement Mills, and continuing to the southeast limit of the gorge. The river here is 700 feet above tide level.

Geology.—The foregoing outline of the topography of the region will enable the reader to understand more clearly its geological peculiarities, and to interpret more readily than he otherwise could, the ideal section accompanying the map.



MAP OF CAÑON AT BALCONY FALLS, VIRGINIA.



SECTION AT BALCONY FALLS, JAMES RIVER.

Conceive a vertical plane with its edge resting on a line represented by the broken line of the map, marked "S.E.," and "N.W.," and having a height of 1500 feet above the bed of the river. Then imagine all the outcropping faces and edges of all the eroded rocks of the gorge, and all that the plane itself would cut (including those of Salling's Mountain), to be pictured on the plane, and you will have a mental conception of what the section is designed to represent.

The student of geology will find here a somewhat intricate, but a very interesting problem for solution. By a series of careful observations along the canal and bed of the river, and also by the turnpike that crosses the mountain near the canal, very satisfactory conclusions may be reached. In the gorge we have the rocks of two distinct eras so meeting as to enable us to study not only their composition and structure, but also their relative positions, and some of the metamorphic influences they have exerted upon one another. These two eras are, (1) the Archæan, represented on the accompanying section by the rocks on the right marked G, S, and 1 *a*, *b*; (2) a portion of the Lower Silurian covering the remainder of the section.

Let us begin at the base of the Archæan. Here we find two masses, or a sort of double mass, marked G. and S.—the former a mass of Granulite, and the latter of Syenite. These are usually regarded as igneous, or perhaps with more propriety, aqueo-igneous rocks. They underlie the stratified rocks of this era; but, considered as solid rocky masses, they are probably of more recent date than any other rocks represented on the section—having been thrust upward beneath the over-lying stratified beds in a plastic (semi-fused) condition, and subsequently hardened into their present condition.

G. is "granulite"*—a granitoid rock, eruptive in its origin. It is composed of granular quartz mixed with feldspar, both white and pale flesh-colored; and has numerous crystals of garnet, and occasional crystals and blotches of epidote disseminated through it, giving it a spotted appearance. This is about 100 feet wide at the base, and seems to be separated from the larger mass of syenite (S.) by a crushed and greatly metamorphosed bed of gneissoid rock, in which distinct traces of the original bedding can be seen. The syenite is well exposed from a short distance below the limit of the granulite, as far down the canal as to lock No. 15. It also forms a rugged bed for the river in this part of its course, and rises to the height of several hundred feet beneath the mountain on the opposite side. Syenite is a granitoid rock composed essentially of quartz, feldspar and hornblende, in varying proportions.

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* So classed by Professor Dana, to whom a specimen was submitted.

Besides these constituents we find the mass at Balcony Falls containing, in some places, considerable quantities of epidote, both crystalline and amorphous, giving the rock a green color, and in others numerous crystals of garnet.

The bedded rocks (1, *a*, *b*,) that rest upon the syenite, are very much metamorphosed, are gneissoid in character, and dip toward the southeast. These are succeeded by beds of red and brown slates. Then follows a bed of forty or fifty feet of conglomerate quartzite, bearing some resemblance to the conglomerate sandstones on the opposite side of the ridge, but so unlike in composition, texture, position and thickness as to preclude the idea that they have any historical connection. Over this again we find another bed of slate. These beds all dip towards the southeast, while their upper margins reach beyond the underlying syenite and granulite, and with their edges support the lowest beds of Primordial rocks where they extend high up on the ridges, beyond the limit of the igneous beds. The two series here, and at other points along the ridge, are entirely unconformable. Such are the Archæan rocks.

Starting again on the northwest side of the granulite, let us briefly sketch the remarkable beds that make up the remainder of this massive range. In the Archæan rocks we have just described there are no traces of fossil remains, nor do we find any in the lowest beds of what we call Primordial. If organic remains have ever been imbedded in them here, they have either been obliterated or remain yet to be discovered.

Subdivisions.—On the section illustrating a former article (July No.), the classification of Professor Rogers in his reports was employed, and subdivisions of my own introduced. In a second article (August No.), the classification and notations* of Professor Dana's Manual were introduced. This latter system I shall employ in this paper—introducing subdivisions only in the Primal period, numbered, 1, 2, 3, etc.

The Primal or Potsdam period is often divided into Acadian and Potsdam epochs—2*a* and 2*b*—but as it is very doubtful whether both of these, as they occur farther north, have equivalents here, or if they have, where the horizon between them is to be found, I shall designate the whole period as 2*a*, *b*, and its subdivisions 1, 2, 3, 4, etc. These will correspond with the subdivisions, 1*a*, 1*b*, 1*c*, etc., on my former section. As these were then regarded as only of secondary importance to my main object—the Silurian limestones—a very brief description of them was deemed sufficient; but now they become of prime importance in our discussion, and demand a more full and detailed examination.

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* Professor Rogers himself has partially adopted this system in his article on the Geology of Virginia, in Macfarlane's Geol. R. R. Guide.

Without repeating in each case the notation, *2ab*, the several subdivisions will be referred to by the simple numbers, 1, 2, 3, etc. All the beds of this period, with some local and limited exceptions, dip toward the northwest. The slight alternations and variations of dip are confined almost entirely to the thinner beds of sandstone, and the shales contiguous to them (especially in 3), and are limited apparently to points near the margin of the river. Variations in the steepness of dip in the heavy beds of sandstone as they rise toward the crests of the ridges, are, however, common throughout the whole range. The limited irregularities may, with much plausibility, be referred to the undermining action of the river; for there are abundant indications that the water once stood several hundred feet higher in this pass, and in the little valley west of its entrance, than the present height of the river bed.

Subdivision 1 is a bed of conglomerate about fifty feet thick, resting unconformably against the Archæan rocks, and composed of sand, rounded quartz pebbles, fragments and worn crystals of feldspar, with some fragments of epidote, all firmly cemented together, and hardened by the action of heat from the contiguous igneous rocks; followed by several alternations of slates and conglomeritic sandstones, with an aggregate thickness of about 120 feet. This division has been considerably affected by heat throughout. Its position, too, has protected it against the erosive action of the river which has been far less here than it has been among the slates higher up in the series.

Number 2 is a heavy mass of sandstone fully 350 feet thick, and so hard that we may call it "quartzite." It consists of three tolerably distinct beds varying in hardness and color; the lowest being very hard and of a light gray, sometimes pinkish color; the middle one of coarser texture, partly conglomerate and mostly of a greenish gray color; the upper bed is more brittle than either of the other two, and of darker color. These heavy beds of hard sandstone seem to have presented one of the most durable barriers to the passage of the river through the mountain, and doubtless obstructed its flow to such an extent as to keep the water in contact with the higher beds for a period long enough to cause some modifications already mentioned, and others to be noticed hereafter. Before the canal was constructed the steep rugged outcrop of this massive ledge projected considerably over the left margin of the river, and was known as "Balcony Rock"—hence the name of the falls. For some little distance on the west side of this sandstone the river runs nearly with the strike of the strata, exposing in succession the rugged edges of the several beds.

Number 3 consists of two heavy beds of slates separated by a stratum of hard conglomeritic sandstone about sixty feet thick, and greenish gray color. The slates are of brown, purple and yellow colors, with some thin beds of argillaceous sandstones interstratified. At this point the river has left some marked traces of its former action in eroding the softer, and undermining the harder strata. The most conspicuous irregularity has been caused by the undermining of the interstratified bed of sandstone just mentioned, so as to give it a low, and sometimes waving dip, and to cause a mass of it to slip from its normal position and modify both dip and strike, as seen just above the margin of the canal. This seems to me the only rational way of accounting for the anomalous position of this bed of sandstone at this point, compared with its position at several other points remote from the river. It also explains its want of conformity with the general structure of the whole Primal period, as exhibited all along this part of the Blue Ridge range. These local irregularities are not represented on the section.

It is a little difficult to determine, even approximately, the thickness of this double bed of slates with its enclosed sandstone, but the aggregate must be at least six hundred feet.

Number 4 is not well defined below, since 3 becomes more and more siliceous and blends gradually into it; but the greater part of it is a bed of brownish gray sandstone with a well defined upper surface. It crosses the river at the Cement Mills, and its highest ledge forms the abutment of the dam on the opposite side of the river. Where a deep channel was washed out by a freshet a few years ago, this rock is well exposed on the lower margin of the turnpike, and its upturned edges may be conveniently examined. A considerable exposure of it also crops out above the turnpike between the houses of Messrs. Locker and Campbell, while the corresponding ledge may be seen on the cliff beyond the river. It has a very regularly jointed structure—the cleavage planes being so distinct as to have been mistaken by an unpracticed observer for planes of stratification dipping to the southeast, while the true planes of stratification dip with considerable uniformity and great constancy toward the N.W.

In this and some of the lower beds of sandstone, very faint impressions of fucoids and occasional Scolithus borings are found; but the conglomerate structure is much less prominent here than in the older beds.

Number 5 is made up of numerous thin beds of slate quite different in color and texture from any that we find lower down. They exhibit, where recently exposed in repairing the canal, a great variety of color from nearly pure white kaolin to various shades of yellow, red and brown, and abound in fine scales of mica; but no distinct traces of fossil remains have been found in them. In the portion near the river their dip varies from 25° to 50°. I estimate their thickness at 180 feet.

Number 6 is, in some respects, the most interesting of all the subdivisions of this Primal group. It is the sandstone that "constitutes the type of this formation." It differs from the beds already described in both its lithological and fossil peculiarities, (see July No., p. 22). It may well be called the "Scolithus sandstone," if we call the primal worms (?) that had their millions of habitations in this rock the "*Scolithus linearis.*"

Its entire thickness (including some quite brittle beds that underlie and overlie the more massive portion), is about 340 feet. The dip at the base of the ridge, where the two rivers meet at the entrance of the gorge, is fully 65°, while it falls gradually to 40° before it reaches the summit—looking as if it might once have been one leg of a grand natural arch, which still stands up with one exposed face forming an almost perpendicular cliff nearly 800 feet in height. There is, however, no point in this portion of the range where I have found it reaching beyond the northwestern line of ridges, of which it generally forms the crest and the greater part of the western slope, as represented on the accompanying section. A part of this sandstone, with the next beds of slate and sandstone below it, has broken loose from the upper outcrop of the ledges on the S.W. side of the river, and slipped down the eastern face of the ridge without any great change of dip. This displaced mass may be seen as a very conspicuous object nearly opposite, though a little below the Cement Mills. It is apparently one of the effects of undermining by high water in the remote past.

Division 7—the upper Potsdam shale—usually extends some distance up the slope of 6, where the normal dip has been preserved, as may be seen at the iron mines a short distance to the N.E., or opposite the Cement quarries, a short distance S.W. of the entrance of the gorge; but just at the entrance it has been eroded by the river and then concealed very much from view by the drift and diluvium of the valley. Its dip increases toward the valley. As nearly as can be determined here, the thickness is fully 600 feet. A sufficient additional description of it may be found in the July number, p. 23. This brings us to the top of the Primordial period.

The next is the Canadian Period (3)—sometimes called, "Middle Cambrian"—and, like the Primordial, belongs to the Lower Silurian Age. It has three epochs, Calciferous (3*a*), Quebec (3*b*) and Chazy (3*c*). The first of these, named from the prominent character of its rocks in New York, might well be called "Hydraulic," in Virginia, as it is generally characterized by the presence of one or more beds of hydraulic limestone. Where our section crosses, this limestone is quarried from a bed twelve or thirteen feet thick, interstratified with shales and other beds of impure limestone. It dips steeply to the northwest, and again crops out at the base of Salling's Mountain, on the west side of the little valley in which the two rivers meet. Over it lies a part of the Quebec (3*b*), that has escaped the denuding agencies that have operated so extensively over the whole of the Great Valley. It crops out at a number of points along the James River near the cement quarries, and along the base of Salling's Mountain. We have thus a synclinal trough of limestone resting upon the Primordial shales and sandstones, which we find rising again on the west side and forming the mass of the bordering mountain.

In a depression of Salling's Mountain, about half-a-mile to the right of the point cut by the section, and where the turnpike leading from Balcony Falls to the Natural Bridge crosses, we find the shales and thin beds of sandstone of 2*ab*, 7, extending to the top of the ridge, but where the mountain is more elevated, the heavy beds of Scolithus sandstones (2*ab*, 6), form the core of the ridge, all dipping steeply to the southeast: while beyond, the mountain shales of 7 again appear, dipping toward the mountain and apparently beneath the sandstone which elsewhere underlies them. Then as we descend into the valley beyond the mountain we again meet with the limestones and interstratified shales of 3*a* and 3*b*, dipping under 7. These facts lead to the conclusion that the mountain is a closed fold of Primordial strata pushed over toward the northwest, so as to invert all the strata on that side, and place the older above the newer. But on crossing a low ridge half-a-mile from the mountain and parallel with it, the limestones appear again on its western side still dipping southeast, but in their normal order. From an examination of this limestone ridge at different points, the conclusion to which my mind is drawn is, that it consists of a closed synclinal fold, the middle portion of which is the lower part of the Chazy (3*c*), all higher beds having been pressed out and subsequently swept off. This part of the section will be readily understood from simple inspection.

Salling's Mountain will serve as a type of a considerable number of nearly parallel outliers of the main Blue Ridge chain, extending for thirty miles toward the southwest; and consisting of arches of the upper Primordial strata of sandstones and slates, as may be seen on the road leading from Buchanan to the Peaks of Otter, or of closed and inverted folds, a conspicuous example of which may be found in the ridge that separates Buford's Valley in Bedford from the Great Valley in Botetourt County, and is here called Blue Ridge, because it is the geographical watershed between the two counties—not because it is a continuation of that ridge geologically.

Ridges of this class generally lie off from one to several miles from the main range, and seem to have been thrust up beneath the limestones of the Canadian Period, the folds of which were probably much shattered at the time, and subsequently worn or swept away, so as to leave the ridges of more durable sandstone naked for some distance down their steep sides, and flanked along both bases by slates and limestones—the latter often occupying narrow valleys or troughs, like the one above described, or like Buford's Valley in Bedford county, traversed by the A. M. and O. R. R., in going from Lynchburg to Salem.

Theoretical considerations.—1. The Primal strata, as well as all those of later date, given on my two former sections, (July and August Nos.), are of oceanic origin, and the sandstones and conglomerates have evidently been deposited over the bottom of shallow water, and most heavily along the margin of an ancient ocean whose shore-line was the Blue Ridge. The earliest of these beds—those found at the very bottom, and for some distance upward in the series, are composed of the debris of still older rocks that composed the ancient shore land, and that seem to have been metamorphosed before they were worn down as material for the Primordial strata; for in the latter we find fragments of metamorphosed slate, with both fragments and crystals of feldspar, epidote, etc., more or less water-worn, mingled and cemented together, but not otherwise differing from the same material, as we now find it broken down by the weather from the metamorphic rocks of the Archæan land.

2. The irregular, unbedded masses of syenite and granulite that constitute the base of the Blue Ridge, have evidently been erupted since the deposition of the Primordial strata. This is evident from the mode of contact of the two classes of rock—the stratified resting at a high dip against the igneous masses; and also from the influence the heat of the igneous rocks has exerted upon the slates and sandstones overlying them. Again, the higher we ascend in the series the fewer traces we find of the metamorphic changes.

3. As far as we can read the records left upon the Silurian rocks from the Primordial upward, mechanical force seems to be entirely inadequate alone, without the aid of heat from other sources, to produce any very great amount of metamorphism. The extent to which the rocks represented on the several sections I have given—especially on the first—have been subjected to bending and pressure, and consequent friction, ought, according to the mechanical theory of metamorphism, to have made the Great Valley of Virginia one vast mass of metamorphic strata. But no such effect has followed. The limestones have their fossils beautifully preserved. The sandstones have

not been changed to quartzite. The shales are still nothing but fragile shales (with a few exceptions); while the embedded limonite iron ores still retain their water of crystallization. There has been metamorphism, but only limited, not general, except so far as it has been produced through other agencies than heat, or even super-heated water under pressure.

4. Such closed folds as we find in Salling's Mountain, and in many localities among the lower Silurian limestones, seem to have been great wrinkles in the strata, pushed upward (or downward in the case of synclines), and then pressed together by mechanical force acting from a southeasterly direction and in a horizontal plane. This is the only way we can plausibly account for the numerous troughs and arches and folds found along the lines of the several sections we have had under discussion.

5. The flexures and folds of course produced numerous fractures, especially in the limestone beds, and thus prepared the way for the action of the denuding agencies that stripped this great limestone valley of thousands of feet of its original covering. As the pressure was most powerful on the margin nearest the Blue Ridge, so we should expect to find there the flattest folds and the most numerous fractures, and consequently the greatest amount of denudation. Such we find to be the case; for in the first place, we find the higher—the Trenton—limestones from the James to the Potomac nearly all gone from that side of the valley; and in the second place, all the waters in this region flow toward that side, until they approach the base of the mountain near which they continue till they find an outlet by some one of the great streams that carry them through the mountains and finally to the Atlantic Ocean.

Water acting alone could hardly have been the cause of the vast amount, and peculiar kind of denudation we find extending over nearly the whole 6,000 square miles of this limestone valley, unless it had swept over it in one vast torrent sufficiently deep and powerful to have carried whole mountain chains before it. A much more probable hypothesis is that ice as well as water was an important agent in bringing about the great changes of surface that have given this valley its wonderful fertility.

There are indications throughout this whole region of two great flood periods, since the close of Paleozoic time, when the great Appalachian revolution left the vast accumulations of stratified rocks of that remote age in essentially the same relative position they now occupy. But further notice of these must be postponed for the present.

ART. LVI.—*On the Character and Intensity of the Rays emitted by Glowing Platinum;* by E. L. NICHOLS, Ph.D. (Göttingen.)

IN 1860, Kirchhoff* issued his well-known paper on the relation between the capacity of bodies for emitting and for absorbing rays. That essay made a new epoch in the science of Radiation. It offered the first complete proof and the first universal expression of a principle which had existed in the minds of scientists, more or less dimly, since the days of Euler.†

Although the results of that treatise have been repeatedly confirmed by the experience of investigators in Optical Science and in the domain of Radiant Heat, there have been, so far as I know, in spite of the interesting character of Kirchhoff's Function I,‡ no attempts to measure its values.

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* Kirchhoff, Poggendorff's Annalen, cix; also, "Untersuchungen über das Sonnenspectrum—Anhang."

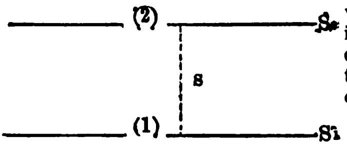
† For earlier attempts to express what is now known as Kirchhoff's Law, see Euler, Opuscula Varii Argumenti, Berol. 1746 (Nova Theoria Lucis et Colorum, Cap. V). Pierre Prevost, Physische-mechanische Untersuchungen über die Wärme, Halle, 1798. Ångstrom, Poggendorff's Annalen, xciv. Balfour Stewart, Proceedings of the Royal Society of Edinburgh, 1857–58.

‡ In the above-mentioned treatise Kirchhoff gives for I the following formula:

$$e = I\frac{w_1 w_2}{s^2}$$

where (fig. 1) w_1 and w_2 are the projections of the openings (1) and (2) in the screens S_1 and S_2, upon planes perpendicular to the axis of a pencil of rays, which, going out from the black body C, passes through both of these openings: where further, s is the distance between the two openings, and e the emissive capacity of a black body. A black body according to Kirchhoff, and the same definition applies to the term when used in this paper, is a body which even when of infinitesimal thickness absorbs all the rays falling upon it. The following short extract from Kirchhoff's paper will serve to define clearly what is to be understood by the terms *emissive capacity*, *absorptive capacity*, etc.

1



"Before a body C (fig. 1) let us suppose two screens S_1 and S_2 to be placed, in which are the openings (1) and (2), of infinitesimal size when compared with the distance between them, and of such shape that each of them may be said to have a center. Suppose the body C to send out a pencil of rays through these two openings. Of this pencil of rays let us consider that portion the wave lengths of which lie between λ and $\lambda + d\lambda$, and let us imagine the same resolved into two components, polarized in the planes a and b. Let the planes a and b pass through the axis of the pencil of rays, and let them be perpendicular to one another. Let, further, $Ed\lambda$ be the intensity of the component a, or, what amounts to the same thing, the increase which the kinetic energy (lebendige Kraft) of the ether behind the screen S_2 suffers in a unit of time by the action of this component. The quantity E is called the *emissive capacity of the body.*" (§2 of Kirchhoff's treatise.)

"Suppose the body C to be black. For its emissive capacity, which in general will be denoted by E, we shall substitute e." (§4.)

In the case where for the black body a body of any other kind is substituted, the equation becomes:

I.

It is the purpose of this paper to describe a series of such researches, made in the Physical laboratory of Professor Helmholtz, at Berlin.

The quantity I is (see preceding foot-note) a function of the wave lengths of the ray and the temperature of the radiating body. Its study, therefore, involves the measurement of the intensity of all wave lengths emitted by the source of light in question, at all temperatures for which the rays are of perceptible energy.

The nature of the subject demands different methods of investigation for the study of the visible and of the invisible rays. The measurements to be described in this paper are confined to the visible rays, and the lowest temperature under consideration is that at which bodies begin to glow.

Two platinum wires 100^{mm} long and about $0{\cdot}4^{mm}$ in thickness, served as sources of radiation. Each formed part of a powerful galvanic circuit, in which the current was produced by a Bunsen's battery. The resistance of each circuit could be varied by introducing or withdrawing copper wire, after the principle of the Wheatstone's bridge. One of these bridges served to compensate for the gradual weakening of the battery, so that the glowing platinum could be maintained at a constant temperature. In the other circuit the platinum wire could be given, by means of the bridge, every temperature from a red heat to the melting point.

It being desired to keep the wire in the first circuit at a constant temperature, a delicate mirror galvanometer was adjusted in this circuit, by means of a very weak branch current. This instrument, when carefully compensated with a bar magnet, showed by the motion of a spot of light upon a screen, two and a half meters distant, every change in the intensity of the current and, of course, in the temperature of the wire. The galvanometer, when properly adjusted, was sufficiently delicate to show unmistakably very much smaller changes of temperature than could be detected either by observing with the eye changes of color in the wire, or by studying with any known instrument the changes in the character of the light emitted. Quite as essential to success as the constant temperature of the wires during a single experiment, is the ability to reproduce in the wires, after interruption of the circuits, exactly their former temperatures.

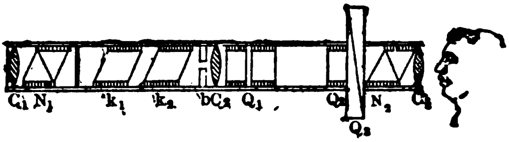
$$\frac{E}{A}=I\frac{w_1\,w_2}{s^2}.$$

Here A denotes the ratio of the intensity of rays absorbed by the body to the whole intensity of the rays falling upon it. In other words, A is the *capacity of absorption* of the body.

To lessen the chances of error I used, in addition to the galvanometer, Kitao's* "Leucoscope," an instrument† admirably adapted for showing qualitative differences in the character of heterogeneous rays. I used the original instrument described in Kitao's treatise. The leucoscope is essentially a polarizer, resembling in some respects Soleil's saccharometer.

"N_1 N_2 (fig. 2) are two Nicol's prisms, k_1 k_2 denote two

2.



exactly similar rhombohedra of calcareous spar, *g* is a plate of mica, thin enough to show colors of the first order, *b* is a slit, the width of which can be altered at pleasure by means of an appropriate adjustment. Q_1 Q_2 are two quartz plates, cut perpendicularly to the optical axis. Q_3 denotes two wedge-shaped quartz plates also cut perpendicularly to the axis. These plates turn the plane of polarization in the opposite direction from Q_1 Q_2. C_1 C_2 C_3 are lenses, the focal distances of which are such as to give a sharp enlarged image of the slit, and of distant objects, the images of which are cast upon the slit by the lens C_1. These parts are set in a tube, blackened on the inside to exclude all foreign and useless light." Light entering the instrument is polarized at N_1, split into two rays by the rhombohedra, so as to form a double image of the slit *b*. As the observer rotates the ocular Nicol N_2, the action of the mica lamina and of the quartz plates gives to the two halves of the double image different tints, alternating between red and green. Whatever be the character of the ray, a thickness of quartz can be found such that at four positions of the ocular Nicol, distant 90° from one another, the two halves assume the same neutral tint. Kitao calls this the point of maximum paleness. This thickness of the quartz plates varies with the composition of the ray, and a means is thus afforded of detecting minute qualitative differences in its light. When the experimenter, having adjusted the instrument for a particular kind of heterogeneous light, turns—without changing the quartz plate—to the observation of rays which differ from those of the first source, he finds that the position of the ocular Nicol corresponding to the maximum of paleness differs for each new kind of light.

A series of experiments were made to test the adaptability

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[*] Diro Kitao, "Zur Farbenlehre, Inaugural-dissertation, Göttingen, 1878.

[†] For a full description of this interesting apparatus, which being a new invention is not so widely known as it deserves to be, I must refer for lack of space to Kitao's paper.

of the leucoscope to this purpose. Its sensitiveness is best shown by the final test, the comparison of two parts of the same petroleum flame. These portions, a cooler and a warmer, were so similar in color that with the unaided eye no difference could be detected. The mean of twenty observations with the leucoscope gave for the position of the ocular Nicol,

TABLE I.

For the upper part of the flame	64° 4′
For the lower part of the flame	62 16
Difference	1 48

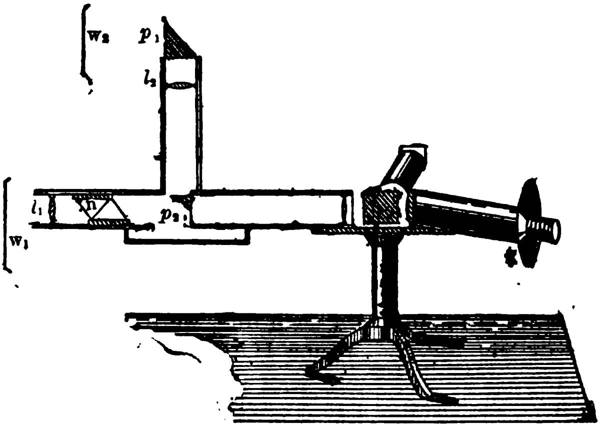
From this it is evident that differences in the quality of rays no longer visible to the eye, can be detected with the leucoscope.

The two platinum wires having been given the desired temperature by a proper adjustment of the Wheatstone's bridges, any change in the character of the light could be at once noticed by means of the galvanometer and leucoscope; and it was easy to determine whether, during the twelve to fifteen minutes course of a single experiment, any important change was caused by the loss of energy in the battery. Experience showed that the loss of intensity during a single experiment was so small that it could be left out of account.

II.

The experiments to be described in this paper were simply spectro-photometric comparisons of the light emitted by the two wires. One of the wires was given successively various temperatures between 1200° and 1900° of the platinum thermometer,* and all visible wave lengths radiated by this wire were compared with the corresponding rays from the other.

3.



* See page 451.

The spectro-photometer used agreed with the already existing instruments in permitting the direct comparison of similar rays. The two horizontally dispersed spectra were vertically one above the other, so that in both equal wave lengths lay in the same line. It differed, however, in various particulars from the spectro-photometers of Vierordt, Glan, and Hüfner. The slit is bisected by the finely ground edge of the small rectangular prism p_2 (fig. 3). The lens l_1 throws an image of the glowing platinum wire w_1 upon the lower half of the slit. The rays of the other wire, w_2, after total reflection in the prism p_1, passage through the convex lens l_2 and a second total reflection in the small prism p_2, form a similar image upon the upper half of the slit. This pencil of rays is not polarized, whereas the rays from w_1 are polarized by passing the Nicol's prism n. Both sets of rays after passing the collimator tube, the large dispersing prism, the telescope and the ocular Nicol, reach the eye in form of two spectra, lying side by side. When the two sources of light are of equal intensity, and the planes of polarization of the two Nicols are parallel, the rays from w_1 suffer less loss in transmission to the eye, and give in consequence the brightest spectrum. Its intensity for all positions of the Nicol is given by the formula

$$I = \cos^2 \alpha, \tag{3}$$

where α is the angle between the planes of polarization of the Nicols. The measurements were made by turning the ocular Nicol until the rays in the two spectra were equally bright. My experience in the use of the instrument was but a repetition of that of former observers. The varying delicacy of the eye at different times and for different colors, especially in the study of the extreme red and violet rays, influenced greatly the accuracy of the measurements.

An ordinary micrometric scale, such as are generally attached to spectroscopes, was used to mark the various spectral regions to be studied, and the position of the principal Fraunhofer's lines upon this scale having been carefully noted, it was made fast, and not moved again during the whole course of the investigations. These positions, according to the mean values of sixteen readings for each line, were as follows:

TABLE II.

Lines.	Scale-divisions.	Lines.	Scale-divisions.
A	7·35	b	12·84
B	8·05	F	14·63
C	8·74	G	19·03
D	9·95	H	23·28
E	12·37	....	....

III.

The accurate determination of the temperature of a glowing platinum wire, presents serious difficulties. Repeated attempts to use Matthiesen's formula for the change of electric resistance with the temperature, only showed the impracticability of this method.

Only the middle portion of a glowing wire can be said to be of equal temperature throughout. If we measure the resistance of the wire when hot and cold (in itself no easy task), the change corresponds to a difference of temperature which gives, so to speak, the *mean* temperature of the whole wire; a quantity which must then be used, together with h and k (inner and outer conductivity of the metal), and with the dimensions of the wire, in the calculation of the distribution of temperature throughout its various parts. Aside from the difficulty of finding an applicable expression for this distribution, our imperfect knowledge of the quantities h and k for platinum, as functions of the temperature, would render the calculation of doubtful value.

The method finally adopted was to measure directly the expansion of the wire. By observing it from end to end with the leucoscope, while glowing, it was found that for a portion in the middle, about 60^{mm} long, the light radiated was, for the whole distance, of like character. This then was the greatest admissible length of the piece to be measured. In reality the section chosen was much shorter (45^{mm}), so that certainly within its limits, only imperceptible differences of temperature occurred.

A degree of the platinum thermometer may be defined as that change of temperature which causes in a platinum wire a linear variation of $1:1{\cdot}00000866$. Then for a wire 45^{mm} long, one degree corresponds to an expansion of about $0{\cdot}0004^{mm}$, and it was desirable in determining the temperature to be able to measure its length to within a few ten-thousandths of a millimeter. For this purpose I used a finely constructed Helmholtz's Opthalmometer; the following description of which is taken from Helmholtz's "Handbuch der physiologischen Optik," (p. 8). "The opthalmometer is essentially a telescope arranged for short distances, before the objective lens of which two glass plates stand side by side, so that one-half of the lens looks through the one, the other half through the other plate. When both plates are in a plane perpendicular to the axis of the telescope, there appears a single image of the object in view. Let them be turned a little, however, toward opposite sides, and the single image divides into two halves of a double image; the distance between which increases with the angle between the plates. This distance can also be calculated from the angle which the plates make with the axis of the telescope."

If a ray pass obliquely through a glass plate its displacement S will be, (fig. 4),

$$S = \frac{\sigma \sin (i - r)}{\cos r} \tag{4}$$

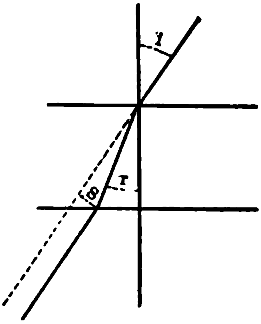
where σ denotes the thickness of the plates,
i denotes the angle of incidence,
r denotes the angle of refraction.
Eliminating r the equation becomes,

$$S\sqrt{1-\frac{\sin^2 i}{n^2}} = \sigma \sin i \left(\sqrt{1-\frac{\sin^2 i}{n^2}} - \frac{\cos i}{n}\right) \tag{5}$$

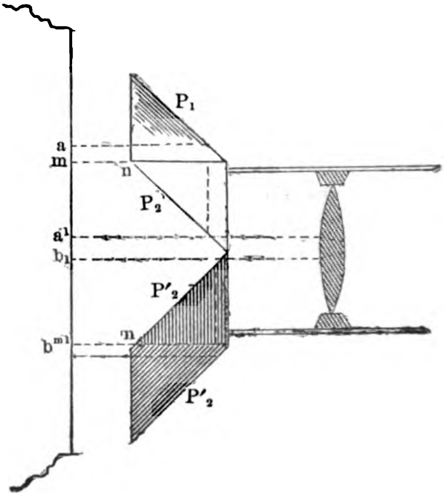
where n is the index of refraction.

The use of the opthalmometer offers great practical advantages over other micrometric methods, in that the angles corresponding to any given distances are independent of the distance of the object measured, and in that any slight unsteadiness of the object does not affect the accuracy of the determination.

4.



5.



The two end-points a and b (fig. 5) of the bit of wire to be measured, were, as already stated, about 45^{mm} apart; and some especial contrivance was therefore necessary to bring both of them at once into the field of the opthalmometer. A system of rectangular prisms $P_1 P_2 P'_1 P'_2$ arranged as shown in fig. 5 served this end. After two total reflections the images $a_1 b_1$ were nearly coincident. Angle readings with the opthalmometer are only possible to tenths of a degree, and I found that 6′ corresponded to a distance of $0{\cdot}003^{mm}$. To obtain greater delicacy I made use of a biconvex lens of as great magnifying power as the case permitted. There was a limit to the possible enlargement, since with too large an image the expansion of the wire when heated sufficed to carry its ends out of the field of vision. In order that any unsteadiness of the wire might remain without influence on the measurements, the lens was attached, not to the opthalmometer, but together with the set of prisms upon the iron holder of the wire, so that possible jarring would effect rather the position than the size of the image. The second advantage of the instrument, that the reduction of angle readings to linear distances is the same whatever be the distance of the object from the eye, unfortunately disappears when the lens is used. The apparent distance between the images $a_1 b_1$ changes with the distance of the opthalmometer from the lens so that it was necessary to adjust the instrument once for all, and to keep it unchanged during the entire series of experiments. When a lens is used, the formula (5) instead of giving the real distance $a_1 b_1$, expresses merely the apparent distance between the images of a and b in the field of sight. The simplest modification consists in substituting another constant, which we shall denote by c for σ. The value of this constant was determined by exchanging the wire for a millimeter scale and noting the angles corresponding to displacements of the double images of ¼, ½, etc., divisions of this scale. The scale was of boxwood and the half millimeters were marked by fine lines. The following table gives the angles corresponding to linear displacements of ⅛, ¼, etc. millimeters. Each result is the mean of six readings.

TABLE III.

S	i
0·125$^{\text{mm}}$	17° 3′ 0″
0·250	32 24 0
0·375	44 54 0
0·500	55 22 12
0·625	64 46 12
0·750	72 28 12

If in formula (5) c is substituted for σ and values from the above table for S and i, we obtain, n being known, from the equation,

$$S\sqrt{1-\frac{\sin^2 i}{n^2}} = c \sin i\left(\sqrt{1-\frac{\sin^2 i}{n^2}}-\frac{\cos i}{n}\right) \qquad (6)$$

the numerical solution,

$$c = 1{\cdot}03097^{\text{mm}}.$$

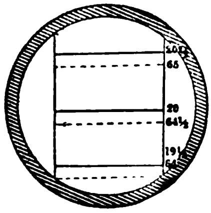
All the data necessary to the measurement of the distance $a_1 b_1$ were thus at hand. The distance $a b_1$ (fig. 5) is, however, $a_1 b_1 + m m_1$. Now the points m and m_1 are coincident in the field of the opthalmometer, appearing to lie at m_2; and their real distance can be measured by simply observing the double images of the above-mentioned scale as they appeared in the field of sight. Images of two parts of the scale were brought by total reflections in the set of prisms into the field (see fig. 6), the portion lying between divisions 19½ and 20½, and overlapping this the portion from division 64 to 65. Now turning the plates of the opthalmometer until the lines 20 and 64·5 coincided, which occurred when the angle was, according to three successive readings, 29°·12′, 29°·18′, 29°·12′, sufficed to show how much the distance $m\,m_1$ exceeded $44·5^{mm}$.

From formula (6) we find,

$$\overline{m\,m_1} = 44·55748^{mm},$$

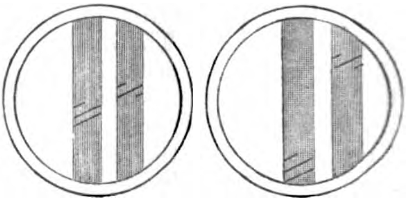
to which quantity it was only necessary to add for any state of the wire the directly obtainable value $a_1\,b_1$, in order to know $a\,b$, the length of the piece of wire in question.

6.



7.

8.



Cold wire. Hot wire.

Having chosen a and b as the end points of the wire to be measured, it was necessary in some way to mark them, so that when the wire was magnified the boundary lines should appear sharp, and at the same time be uninfluenced by the highest temperatures to which the metal was to be submitted. An indentation, be it ever so fine, will not only influence the temperature of the wire, but will even cause it to melt and break before the other portions have acquired the proper degree of heat. A ridge has the opposite effect, causing, in consequence of the increased conductive power, a dark ring upon the glowing metal. I employed, among other devices, minute glass beads, fused upon the wire in the desired places. This plan served very well at low temperatures, as it gave sufficiently sharp boundaries of demarkation; but as the heat increased, the melting of the glass next the metal destroyed the fineness of the boundary. It even happened at times that the entire bead would slip along to a new position on the wire. The following method, on the contrary, answered admirably. At the proper points simple loops of exceedingly thin platinum wire* ($0·03^{mm}$ in diameter) were thrown around the larger wire. The latter having been brought to a white heat by means of the current, the loops were drawn tight at their appointed places. The small wire, fine as a fiber of raw silk, and scarcely visible to the naked eye, melted on touching the hot metal and became fixed upon its surface. The whole, seen through the microscope, appeared as in figs. 7 and 8. Since all the observations were made in a dark room, where, in the case of the cold wire, the marks would have been invisible, two small gas-flames were so placed that their rays, reflected from the loops of wire, appeared in the dark field of vision like two fine points of light. Such was the apparatus by means of which the temperatures given in the table of results were measured. It afforded all desired accuracy. The opthalmometer is free from many errors which by cathetometric and micrometric measurements are unavoidable.

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* This wire is prepared for use in the construction of electrometers.

The temperatures used varied from 1200° to 1900° of the platinum thermometer. Shortly after passing the latter point the platinum suffered a change of condition. It did not melt; but the wire lost its stiffness, hung down limp, scarcely holding together, and quivered when jarred like jelly. Under these circumstances measurements became unreliable. The very small weight* which hung at the lower end sufficed, as soon as the current became a trifle stronger, to stretch the wire in its weakest place. The conducting power being thus diminished, the temperature would rise very rapidly until after glowing brilliantly for a moment, the platinum would melt and the wire break.

IV.

Before the beginning of the experiments the two wires were adjusted in their iron holders before the slit of the spectrophotometer, which having been brought into its proper place and sealed fast, was not moved during the whole course of the investigation. The opthalmometer also, having been placed in the position most advantageous for the measurement of the expansion of the platinum wire, remained undisturbed throughout all the experiments. The leucoscope was set up two meters distant from the two wires.

The galvanic circuits of which the wires formed a part having been closed, and the few minutes necessary for the attainment of a constant temperature having elapsed, the deflection of the galvanometer and the condition of the constant wire as indicated by the leucoscope were noted. The temperature of the other wire was determined by the method described in the last paragraph, and then the spectro-photometric comparison of the rays emitted by the two wires carried out as rapidly and accurately as possible. Beginning with the wave lengths denoted by the scale-division 8 (see Table II), this being the point nearest the red end of the spectrum at which satisfactory results could be obtained, the intensities of the two spectra were compared in the spectral regions corresponding to divisions 9, 10, etc., to 19 in the neighborhood of line G_1 successively. Beyond 19 no accurate readings were possible.* The same measurements were then made in reverse order, from violet to red, and finally a second time from red to violet, and the mean values of these readings used.

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* If both ends of a cold platinum wire be fastened, and the wire be made to glow, the expansion resulting from this change of temperature suffices to move its center considerably from its original position. To avoid disturbance from this cause I fastened only one end of my wires, and inserted the lower ends into short copper rods, which dipped into small vessels of mercury. To prevent heating, the mercury vessels were placed in cold water.

After the completion of these readings the temperature of the wire was again taken, first in its glowing condition, and then, the circuit having been broken and time allowed for cooling, while cold. The deflections of the galvanometer and the temperature of the room were next noted, and last of all the constant wire again observed through the leucoscope. Whenever a difference in the measurements before and after an experiment pointed to a change of temperature in either wire, the experiment was set aside as imperfect.

The readings given in the following table will suffice to show the general character of the measurements.

TABLE IV.†

Scale-divisions.	Readings.	Mean.	90° — *a*.	Intensity.
8	37°·0 36 ·8 37 ·2	37°·00	20° 36′ 0″	·1238
9	36 ·0 36 ·3 36 ·0	36 ·10	19 42 0	·1136
10	32 ·5 33 ·5 32 ·9	32· 97	16 34 12	·08133
11	30 ·0 30 ·0 31 ·0	30 ·33	13 56 0	·05798
12	29 ·0 28 ·9 29 ·0	28 ·97	12 34 12	·04736
13	27 ·5 27 ·4 27 ·0	27 ·30	10 54 0	0·3576

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* For the lower temperatures used, the spectrum was not visible even to line G, and measurements could only be carried out up to the scale-division nearest the limit of the visible rays.

† The figures in the column marked "Readings" denote the position of the pointer attached to the ocular Nicol. Subtracting from the mean of these readings for each part of the spectrum the position of the pointer when the Nicols are crossed, the quantity 90° — *a* is obtained. 90° — *a* being the angle between the planes of polarization of the two Nicols.

Scale-divisions.	Readings.	Mean.	90° — *a*.	Intensity.
14	25 ·9 26 ·7 26 ·4	26 ·33	9 56 0	·02976
15	24 ·0 23 ·3 24 ·3	23 ·87	7 28 12	·01696
16	24 ·0 23 ·5 24 ·0	23 ·83	7 25 48	·01600
17	----	----	----	----
18	----	----	----	----
19	----	----	----	----

From the 17th division onward the intensities were too small to allow of further measurements.

The other readings in the above experiment were as follows:

Before.

Leucoscope-readings		40°·6	40°·3
Opthalmometer-readings (for the hot wire,		56°·5	

After.

Leucoscope-readings		40°·5	40°·4
Opthalmometer-readings (for the hot wire)		56 ·5	56 ·5
Opthalmometer-readings (for the cold wire)	29°·4	29°·5	29°·5
Movement of the galvanometer during the experiment*			4cm
Temperature of the room			20°·1 C.

Applying the above readings in formula (6) we find as temperature of the hot wire 1539°·5 (of the platinum thermometer). I succeeded in obtaining thirteen such series of measurements at temperatures varying from 1932° to 1201°,† and covering wave lengths from scale-division 8 and the end of the visible spectrum in the direction of the violet. These results are given in the column marked "Observed," Table V. They can be approximately represented by curves the abscissæ of which are temperatures and whose ordinates are the corresponding quantities in the column marked "Calculated." The differences between the observed and calculated values are given in a separate column.

Table V.

Region 8 on Kirchhoff's Scale 609·1.

Temp. (°)	Observed.	Calc.	Diff.	Temp. (°)	Observed.	Calc.	Diff.
1201·1	0·001	0·004	+ ·006	1628·8	0·290	0·288	+ ·002
1256·9	0·006	0·005	+ ·001	1653·0	0·383	0·350	+ ·033
1358·3	0·041	0·026	+ ·015	1759·6	0·623	0·623	·000
1426·4	0·030	0·037	+ ·007	1901·7	1·421	1·417	+ ·004
1539·5	0·123	0·145	— ·008	1932·7	1·760	1·959	+ ·001
1618·5	0·288	0·257	+ ·037				

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* A movement of the spot of light over 1·25 meters corresponded to a change of temperature in the wire sufficient to be detected by the leucoscope. 4cm denoted a negligible decrease in temperature.

† Draper (Philosophical Magazine, xxx, 345) gives 525° C. as the point of temperature at which visible rays begin to appear. Granting the accuracy of this measurement, we find a long interval of at least 600° within which the intensity of even the red rays is exceedingly small compared to their intensity at 1900°. So far as the present method goes, they are immeasurably small.

Region 9 on Kirchhoff's Scale 813.

Temp. (°)	Observed.	Calc.	Diff.	Temp. (°)	Observed.	Calc.	Diff.
1201·1	0·004	0·003	+·001	1653·0	0·295	0·296	—·001
1256·9	0·004	0·004	·000	1689·7	0·341	0·389	—·048
1358·3	0·003	0·020	—·0165	1759·6	0·580	0·582	—·002
1426·4	0·0185	0·033	—·015	1901·7	1·411	1·409	+·002
1539·5	0·113	0·105	+·008	1932·7	1·740	1·739	+·001
1618·5	0·241	0·230	+·011				

Region 10 on Kirchhoff's Scale 1007.

1201·1	0·004	0·0028	+·0012	1628·8	0·207	0·216	—·009
1256·9	0·003	0·0035	—·0005	1653·6	0·249	0·257	—·008
1358·3	0·023	0·018	+·005	1759·6	0·572	0·565	+·007
1426·4	0·0162	0·025	—·0088	1901·7	1·395	1·370	+·025
1539·5	0·081	0·086	—·005	1932·7	1·698	1·695	+·003
1618·5	0·199	0·198	+·001				

Region 11 on Kirchhoff's Scale 1221.

1201·1	0·003	0·0025	+·0005	1628·8	0·204	0·197	+·007
1256·9	0·003	0·003	·000	1653·6	0·241	0·240	+·001
1358·3	0·0181	0·0125	+·0056	1689·7	0·307	0·314	—·007
1426·4	0·0151	0·0189	—·0038	1759·6	0·545	0·536	+·009
1504·8	0·048	0·047	+·001	1901·7	1·339	1·330	—·011
1539·5	0·058	0·076	—·018	1932·7	1·668	1·666	+·002
1618·5	0·170	0·170	·000				

Region 12 on Kirchhoff's Scale 1422.

1201·1	0·003	0·002	+·001	1618·5	0·130	0·135	—·005
1256·9	0·002	0·0025	—·0005	1653·6	0·220	0·200	+·020
1358·3	0·014	0·010	+·004	1689·7	0·267	0·271	—·004
1426·4	0·013	0·012	+·001	1759·6	0·523	0·486	+·037
1504·8	0·0139	0·0136	+·0003	1901·7	1·375	1·313	+·002
1539·5	0·047	0·063	—·016	1932·7	1·666	1·665	+·001

Region 13 on Kirchhoff's Scale 1629.

1201·1	0·002	0·0015	+·0005	1628·8	0·154	0·140	+0·14
1358·3	0·008	0·007	+·001	1653·6	0·161	0·173	—·012
1426·4	0·009	0·008	+·001	1689·7	0·236	0·240	—·004
1504·8	0·035	0·020	+·015	1901·7	1·225	1·225	·000
1539·5	0·036	0·038	—·002	1932·7	1·620	1·610	+·010
1618·5	0·109	0·125	—·016				

Region 14 on Kirchhoff's Scale 1833.

1201·1	0·001	0·001	·000	1653·6	0·154	0·151	+·003
1358·3	0·006	0·005	+·001	1689·7	0·208	0·210	—·002
1426·4	0·007	0·007	·000	1759·6	0·409	0·400	+·009
1504·8	0·029	0·022	+·007	1901·7	1·180	1·176	+·004
1618·5	0·091	0·101	—·010	1932·7	1·595	1·590	+·005
1628·8	0·133	0·118	+·015				

Region 15 on Kirchhoff's Scale 2037.

1358·3	0·005	0·005	·000	1628·5	0·114	0·099	+·015
1426·4	0·006	0·006	·000	1653·6	0·153	0·130	+·023
1504·8	0·019	0·013	+·006	1759·6	0·351	0·350	+·001
1539·5	0·018	0·015	+·003	1901·7	1·150	1·146	+·004
1618·8	0·073	0·080	—·007	1932·7	1·550	1·550	·000

Region 16 on Kirchhoff's Scale 2241.

1358·3	0·004	0·004	·000	1628·8	0·074	0·069	+·005
1426·4	0·006	0·005	+·001	1689·7	0·132	0·133	—·001
1504·8	0·013	0·010	+·003	1759·6	0·304	0·304	·000
1539·5	0·017	0·017	·000	1901·7	0·959	0·960	—·001
1618·5	0·067	0·059	+·008	1932·7	1·506	0·508	—·002

Region 17 on Kirchhoff's Scale 2445.

Temp. (°)	Observed.	Calc.	Diff.	Temp. (°)	Observed.	Calc.	Diff.
1504·8	0·010	0·009	+·001	1759·6	0·290	0·280	+·010
1539·5	0·017	0·015	+·002	1901·7	0·891	0·891	·000
1618·5	0·054	0·056	—·002	1932·[illegible]	1·320	1·321	—·001
1689·7	0·108	0·108	·000				

Region 18 on Kirchhoff's Scale 2648.

Temp. (°)	Observed.	Calc.	Diff.	Temp. (°)	Observed.	Calc.	Diff.
1653·6	0·067	0·050	+·017	1901·7	0·795	0·799	—·004
1689·7	0·112	0·080	+·032	1932·7	1·249	1·249	·000
1759·6	0·274	0·240	+·034				

Region 19 on Kirchhoff's Scale 2853.

Temp. (°)	Observed.	Calc.	Diff.	Temp. (°)	Observed.	Calc.	Diff.
1689·7	0·060	0·059	+·001	1901·7	0·750	0·750	·000
1759·6	0·207	0·202	+·005	1932·7	1·203	1·200	+·003

The size of the above differences bears witness to the difficulties which, aside from those which are unavoidable, even in the study of the most favorable colors at intensities best adapted to the eye, stand in the way of accurate results. At the lowest temperatures, where the weaker spectrum had only a few thousandths the intensity of the other, exactness was quite out of the question. How vastly the eye varies in delicacy according to the color of the light, is shown by the following measurements of the intensity of various rays necessary to produce in the eye the perception of color. One finds upon turning the ocular Nicol from the position of maximum brightness to that where the ray becomes completely extinguished, that in the case of the red rays on the one hand and of the blue and violet on the other, this point is much sooner reached than with the yellow and green rays. The position of the ocular Nicol, at which each ray of the spectrum disappears, is given in the column marked "$90° - a$" of table VI. The corresponding intensities are shown under "$\sin^2(90 - a)$" and in the column marked "optical action" is given the power of the respective rays upon the eye.

TABLE VI.

Region.	$(90 - a)°$	$\sin^2(90 - a)$	Optical action.	Region.	$(90 - a)°$	$\sin^2(90 - a)$	Optical action.
7	7·32	0·01719	0·1782	14	3·54	0·04620	0·0662
8	1·45	0·00932	0·3284	15	5·0	0·07592	0·0432
9	1·6	0·00363	0·6601	16	7·24	0·16560	0·0184
10	1·0	0·00306	1·0000	17	8·30	0·21600	0·0142
11	2·6	0·01340	0·2281	18	9·36	0·27801	0·01117
12	2·18	0·01611	0·1900	19	12·36	0·44662	0·0068
13	2·42	0·02221	0·1380	20	15·36	0·72320	0·0023

These results are introduced here, to show with what immense subjective differences we have to do in studying the visible spectrum. However valuable such researches might prove to show remarkable variations of the eye with regard to its perceptive power for various colors, these very changes render the experiments useless in the investigation of the real energy of the rays themselves.

In table V the intensities of the various wave lengths for all the temperatures in question are expressed in terms of the intensities of corresponding wave lengths of a similar spectrum of constant but unknown temperature. For each individual ray, the measurements give the change of intensity resulting from a given change of temperature; but since the relative intensity of the various wave lengths of the spectrum of constant temperature are unknown, it is impossible to compare rays of different wave length with each other.

Before describing the way in which all the above results were reduced to a common basis for the purpose of comparison, a clear definition of the expression "intensity of ray" as used in this paper is desirable.

It is first of all essential to distinguish between the intensity of the ray itself and the intensity of its various effects upon bodies upon which it may fall. It is usual to define as the intensity of the ray itself, its energy of vibration or the square of the amplitude of vibration. Kirchhoff however (§ 2 of his above mentioned treatise), defines as the energy of the ray passing the openings of the screens S_1 and S_2 (fig. 1) the increase in a unit of time of the vis viva of the ether behind the second screen. This definition is the more appropriate to the case at hand. Suppose that for the opening S_2 a black body be substituted. In accordance with the principle of the Conservation of Energy, as expressed in the usual equation,

$$T_1 - T_0 = \int_{t_0}^{t_1} \Sigma (X\,dx + Y\,dy + Z\,dz) = U_1 \qquad (7)$$

where T_1 and T_0 are the energy (*lebendige Kraft*) before and after the interval of time, and U_1 denotes the work performed; the increase in energy in the body equals in the unit of time, the work performed by the action of the ray. We may then consider this work as the measure of the intensity of the ray itself. Suppose further, the body be molecularly so constituted that no chemical action takes place, that in short the entire energy of the ray be converted into heat. The amount of heat produced may in this case be taken as the measure of the intensity of the ray itself. This heat, as denoted by the change of temperature of the body, is the result of what is termed the thermal action of the ray, so that the intensity of the ray itself, which I shall call the *mechanical intensity of the ray*, because it is directly expressible in units of work,—is proportional to the intensity of the thermal action, or the *thermal intensity of the ray.*

The *chemical** and *optical intensities of the ray* stand in as yet unknown relation to the mechanical intensity. They are only known in connection with a small class of substances, the optical action seeming to affect a single body only (the retina of the eye). They occur only in certain limited sets of rays, and depend largely for their effect upon the nature and condition of the body acted on. They are therefore useless as measures of the mechanical intensity.

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* Clerk Maxwell, Theory of Heat, p. 240, offers a very ingenious suggestion as to the real nature of the chemical action of light. "It is probable that when the radiation produces the photographic effect, it is not by its energy doing work on the chemical compound, but rather by a well-timed vibration of the molecules dis-

The intensities given in Table V are, however, simply expressions for the square of the amplitudes, and therefore directly proportional to the thermal actions of the respective rays. The thermal intensities of these rays being, at the temperatures available, too small for direct measurement, the easiest way of determining their values is by making a spectrophotometric comparison with the corresponding rays of the sun's spectrum, the thermal intensities of which have been most carefully measured. The best determinations of the sun's spectrum are by Lamansky,* whose results for the visible rays, with the dispersion of a crown-glass prism, are, when adapted to the scale used in my researches as follows:

TABLE VII.

Region.	On Kirchhoff's Scale.	Thermal Intensity.	Region.	On Kirchhoff's Scale.	Thermal Intensity.
8	609·1	0·826	14	1832	0·302
9	813	0·703	15	2037	0·245
10	1017	0·605	16	2241	0·200
11	1221	0·530	17	2445	0·163
12	1422	0·453	18	2628	0·130
13	1629	0·375	19	2853	0·099

The unit in this table is the intensity at the point of maximum heat for the whole spectrum, which lies beyond the last of the visible red rays.

The comparison of the sun's spectrum with that of the platinum wire was made in this way. Diffuse daylight—as reflected from white clouds was used instead of the direct rays of the sun, repeated trials with the leucoscope having shown these to be of identical composition. The pencil of this light was substituted for the rays from the platinum wire of constant temperature. The other wire was given a temperature of 1607° (platinum thermometer), and the measurements were made in a manner precisely similar to that already described. Table VIII contains the readings and results of this comparison.

lodging them from the almost indifferent equilibrium into which they had been thrown by previous chemical manipulations, and enabling them to rush together according to their more permanent affinities so as to form stabler compounds." If this be true, we have evidently to do with work arising from energy stored up by previous chemical action, and therefore not all ascribable to the energy of the ray.

* Lamansky, Poggendorff's Annalen, cxli.

TABLE VIII.

Comparison of the sun's spectrum with that of glowing platinum.

Region.	Reading.	Mean.	9° − a.	Intensity.
8	106°·3 106·5 106·4	106°·4	90° 0′	1·000
9	99·0 98·4 99·6	99·0	72 36	0·91057
10	67·0 68·0 67·5	67·5	51 6	0·60570
11	45·0 44·0	44·5	28 6	0·22185
12	37·0 37·0	37·0	20 36	0·12380
13	31·9 32·9	32·4	16 0	0·07600
14	30·0 30·0	30·0	13 36	0·05529
15	27·5 27·0	27·25	10 43	0·03457
16	26·2 25·8	26·0	9 36	0·02781
17	23·9 24·0	23·95	6 33	0·01300
18	22·1 21·9	22·0	5 36	0·00951
19	20·0 20·0	20·0	3 36	0·00394

With the help of these measurements and of Lamansky's results just given, the intensities of the platinum spectrum for the various temperatures can be reduced to a common unit, and the results in this new form made to express not only the influence of temperature upon each ray considered separately, but, what is equally important, the relations between the intensities of all visible wave lengths by constant temperature.

Using the values, in the column marked "calculated" (Table V), I have constructed a table which gives for intervals of 25°, from 1200° to 1900° (platinum thermometer), the intensities corresponding to the wave lengths between scale-divisions 8 to 19 in terms of the intensity of the spectral-region corresponding to division 10 when the platinum was at 1900°. This value was chosen as the unit because the position of division 10 could be simply and accurately defined. This region corresponds so nearly with line D, that it may be defined as *the region bordering on line D, on the side nearest the violet.* This table (IX) which may be, not inaptly, termed *Isothermic*, is arranged according to temperatures.

TABLE IX (Isothermic).

Regions.		Intensity.							
		1900°	1875°	1850°	1825°	1800°	1775°	1750°	1725°
8 or	609·1$^{\text{mm}}$	1·7071	1·4285	1·234	1·078	0·9470	0·830	0·732	0·637
9	813	1·2102	1·026	0·874	0·748	0·6322	0·552	0·480	0·416
10	1017	1·0000	0·852	0·721	0·606	0·5147	0·436	0·379	0·322
11	1221	0·3665	0·315	0·269	0·257	0·1844	0·150	0·123	0·096
12	1422	0·1975	0·163	0·149	0·115	0·0946	0·076	0·064	0·055
13	1629	0·1086	0·089	0·076	0·063	0·0512	0·042	0·034	0·027
14	1833	0·0758	0·058	0·052	0·046	0·0351	0·030	0·025	0·019
15	2037	0·0445	0·036	0·033	0·027	0·0216	0·018	0·016	0·013
16	2241	0·0391	0·027	0·024	0·020	0·0176	0·013	0·010	0·008
17	2445	0·0282	0·019	0·015	0.013	0·0123	0·006	0·005	0·004
18	2648	0·0256	0·014	0·011	0·009	0·0108	0·003	0·0025	0·002
19	2853	0·0160	0·008	0·005	0·004	0·0071	0·0015	0·0012	0·0007

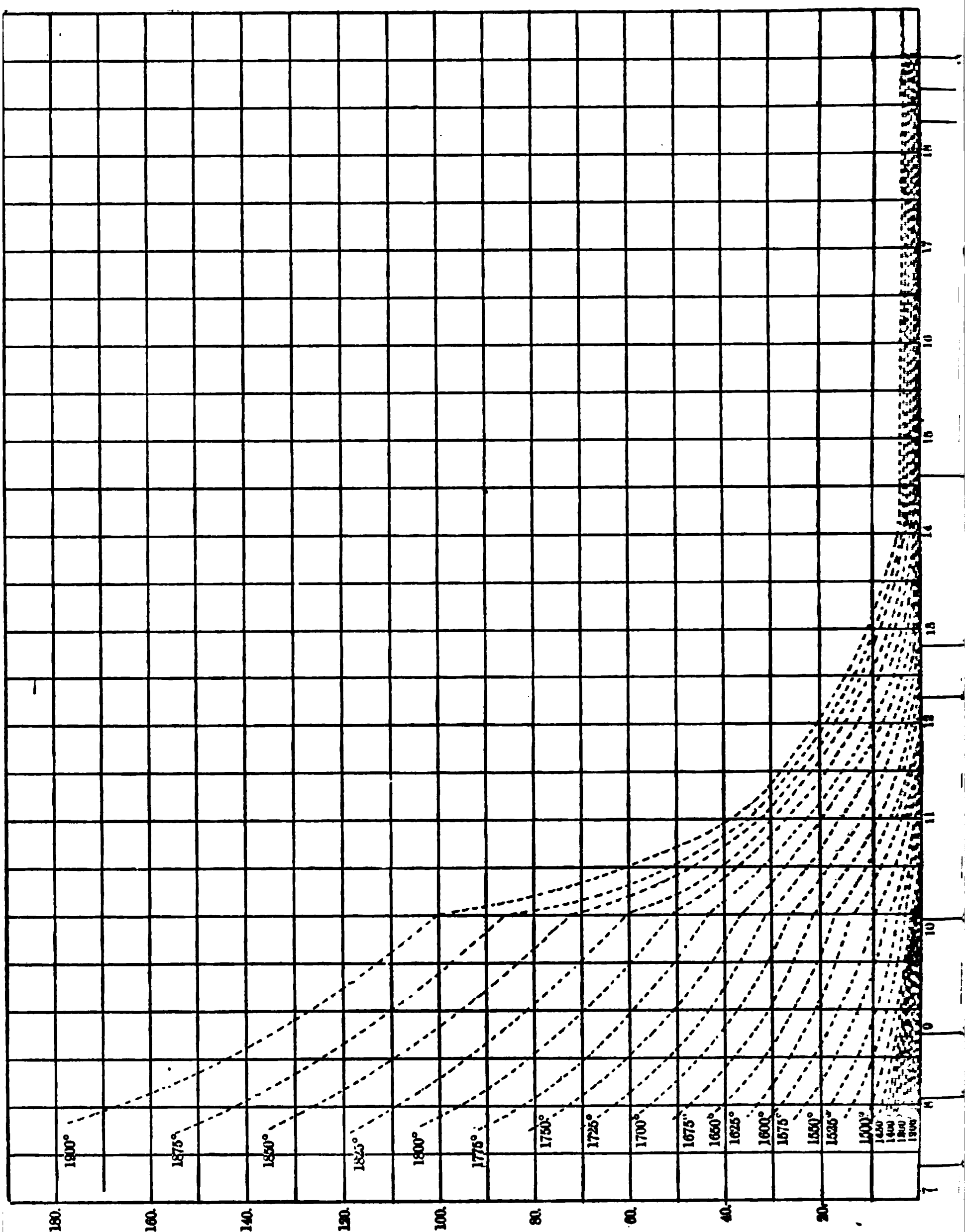
		1700°	1675°	1650°	1625°	1600°	1575°	1550°	1525°
8 or	609·1$^{\text{mm}}$	0·5512	0·472	0·395	0·326	0·2719	0·214	0·169	0·131
9	813	0·3667	0·304	0·256	0·210	0·1694	0·128	0·100	0·076
10	1017	0·2774	0·228	0·187	0·155	0·1221	0·092	0·068	0·052
11	1221	0·0668	0·052	0·042	0·033	0·0277	0·023	0·020	0·016
12	1422	0·0447	0·037	0·027	0·021	0·0183	0·0170	0·015	0·007
13	1629	0·0238	0·016	0·014	0·012	0·0093	0·007	0·006	0·004
14	1833	0·0131	0·012	0·009	0·006	0·0054	0·003	0·0025	0·0015
15	2037	0·0075	0·007	0·005	0·004	0·0027	0·0025	0·0020	0·0010
16	2241	0·0061	0·005	0·002	0·002	0·0018	0·0016	0·0013	0·0007
17	2445	0·0037	0·0005	0·0009	0·0009	0·0007	0·0007	0·0005	0·0004
18	2648	0·0029	0·0006	0·0005	0·0004	0·00025	0·00022	0·0020	0·0001
19	2853	0·0017	0·0004	----	----	----	----	----	----

		1500°	1475°	1450°	1425°	1400°	1375°	1350°	1325°
8 or	609·1$^{\text{mm}}$	0·0922	0·067	0·056	0·047	0·0388	0·032	0·027	0·022
9	813	0·0576	0·046	0·037	0·028	0·0227	0·0170	0·0119	0·0113
10	1017	0·0382	0·029	0·026	0·020	0·0176	0·0121	0·011	0·008
11	1221	0·0120	0·0113	0·011	0·009	0·0043	0·004	0·004	0·003
12	1422	0·0046	0·003	0·0025	0·002	0·0018	0·0015	0·0012	0·0003
13	1629	0·0019	0·001	0·0008	0·0005	0·0015	0·0004	0·00035	0·00021
14	1833	0·0009	0·0007	0·0005	0·0002	0·00019	0·00017	0·00015	0·00010
15	2037	0·0005	0·0004	0·0003	0·00015	0·00007	0·00006	0·0005	----
16	2241	0·0002	0·00017	0·00014	0·00009	0·00004	----	----	----
17	2445	0·0006	0·0006	..	----	----	----	----	----
18	2648	0·0003	----	----	----	----	----	----	----
19	2853	----	----	----	----	----	----	----	----

		1300°	1275°	1250°	1225°	1200°	....	....	....
8 or	609·1$^{\text{mm}}$	0·0182	0·017	0·015	0·012	0·0097	----	----	----
9	813	0·0096	0·008	0·006	0·005	0·0043	----	----	----
10	1017	0·0046	0·004	0·002	0·0018	0·0013	----	----	----
11	1221	0·0009	0·0007	0·0006	0·0005	0·00038	----	----	----
12	1422	0·0002	0·00015	0·0001	----	----	----	----	----
13	1829	0·0000	0·00007	----	----	----	----	----	----
14	1833	----	----	----	----	----	----	----	----

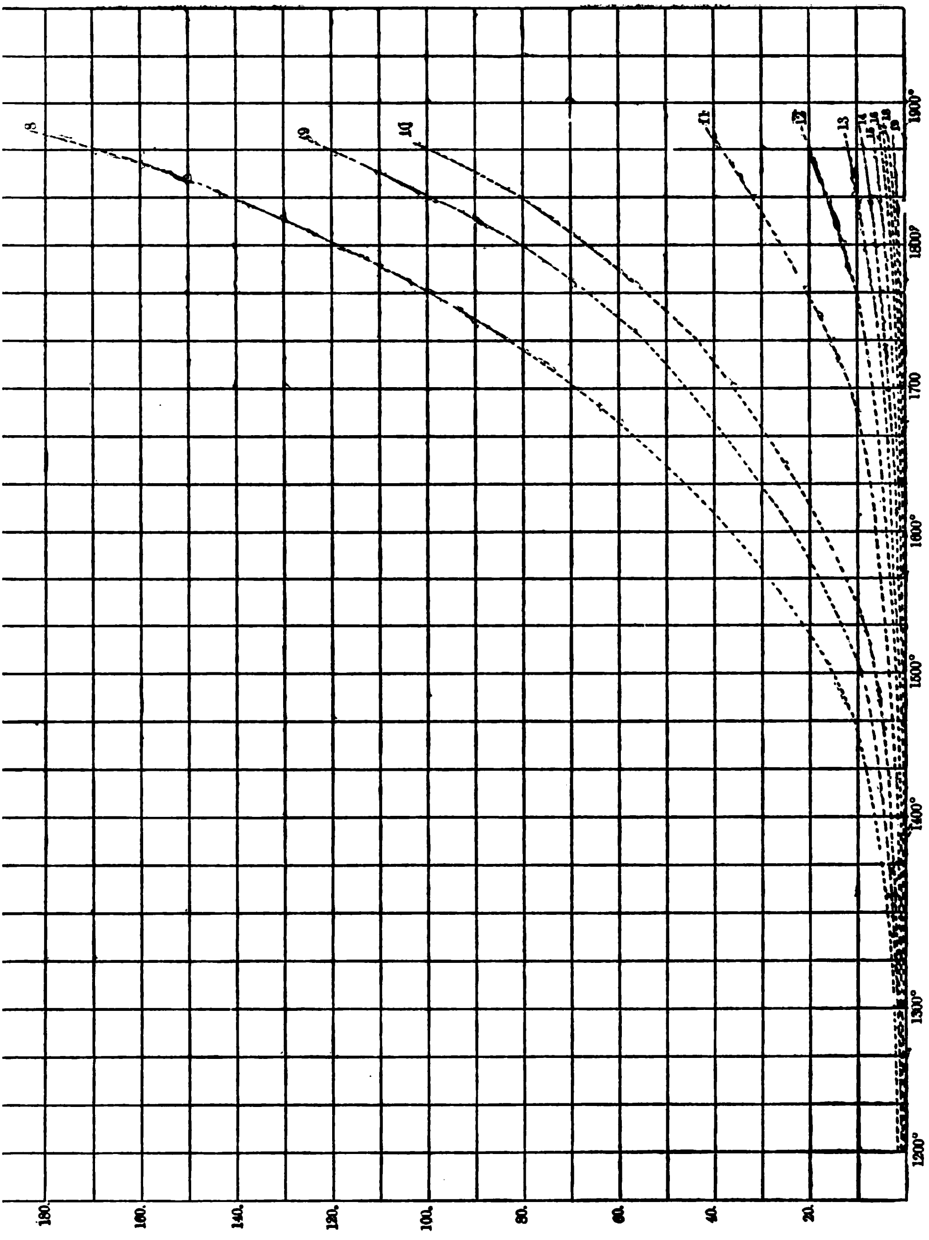
The two sets of curves constructed from this table serve to render the character of these results more evident. In Diagram A, are drawn *Isothermals*, curves of equal temperature, in which the abscissæ are wave lengths, the ordinates intensities. Diagram B, gives the *Isochromatics*, or curves of equal wave lengths, with temperatures as abscissæ and intensities as ordinates. The first set shows the

DIAGRAM A.



Isothermals.

DIAGRAM B.



Isochromatics.

comparative intensities of the various parts of the visible spectrum by constant temperature, the latter denotes the influence of variations of temperature upon the intensity of each individual series of rays.

How exceedingly small the intensity of the more refrangible rays is, even at 1900°, compared with that of the spectral regions between line D and the red end of the spectrum, is equally evident in both sets of curves. A striking peculiarity of the isothermals is the too large value of the intensity of region (10). This unlooked-for feature can scarcely be due to a corresponding irregularity in the platinum spectrum, and at the same time it is in all probability no accidental error. Such an error, in order to produce such an effect in *all* the isothermic curves, must be looked for either in my comparison of the sun's spectrum with that of the platinum wire, or in Lamansky's measurements of the sun's heat. As to the former, we find by reference to the table, that the result in question is calculated from the mean of three readings of fair agreement. An error of several degrees in these determinations would be necessary to bring about any such irregularity as exists in the curves. Lamansky's results are also the mean of numerous measurements, and the occurrence of so large an error just at this point would at once be detected.

A curious fact recorded by Vierordt* while studying the spectra of gases, offers, I think, the true explanation of the irregularity. He observed, that even in absorptions-spectra, with clearly defined lines, no real discontinuity in the intensity of contiguous rays occurs, that, on the contrary, very sudden, but perfectly continuous, changes take place at the edge of each bright or dark line. The region (10) corresponds however, to the edge of the line D, (see pages 13 and 40), and would consequently in the sun's spectrum be weaker, owing to the proximity of the absorption line, than in a perfectly continuous spectrum. In the platinum spectrum, on the other hand, this region would possess its normal brightness, or in case, as generally happens, the surrounding atmosphere contained a trace of sodium, would form the edge of a bright line D, and be of more than normal intensity. This fact would tend, in the comparison of the spectra, to the production of just such an irregularity as appears in the curves on Diagrams A and B.

Kirchhoff, in his treatise (§ 15), draws the following *à priori* conclusions from his discussion:

"If a body, a platinum wire for example, is gradually heated, it emits until attaining a certain temperature, only rays the wave lengths of which are greater than those of the visible spectrum. At a certain temperature, rays of wave lengths corresponding to the extreme red begin to appear. As the body becomes hotter and hotter, rays of shorter and shorter wave lengths show themselves, so that for each temperature a new set of rays first makes its appearance, while at the same time, the intensity of those already at hand continues to increase. Applying the principle we have already proved to this case, we see that the function I for any given wave length is equal to 0 for all points below a certain temperature corresponding to this wave length; and that for all temperatures above this point, the function I increases with the temperature."

---

* Vierordt, Poggendorff's Annalen, 151.

Strictly speaking, however, the temperature at which each individual wave length becomes visible depends solely upon the sensitiveness of the observer's eye. We are furthermore forced to conclude from the experiment recorded in table VI, that the more refrangible rays really exist at temperatures far below those at which we begin to see them. The directions of the curves (Plates I and II) seem to denote, that all the rays studied begin to be emitted at some temperature not included in the interval embraced by the experiments. I suspect indeed that all of them originate at some very low degree (the absolute zero?) and are recognizable no sooner, simply because the various instruments at command, the thermopile, eye, photographic plate, etc., are not more delicate. That the various colors do not appear simultaneously, follows from the very different degrees of sensitiveness shown by the eye for different rays.

A fuller discussion of the results given in this paper, of their application in the study of the function I, and of an optical method, based upon them, for the measurement of high temperatures, will be given in another article. I will conclude with a single remark concerning the scale of temperatures used in this paper.

In view of the present ignorance of the law of expansion for platinum at high temperatures, it seemed better instead of trying to reduce my measurements to Celsius' degrees of the air thermometer, to constitute by means of a simple definition a scale for the platinum thermometer, which should be quite independent of other standards, and which could easily be expressed in terms of the existing scales so soon as the necessary investigations of the expansion of platinum had been made.

The already existing researches extend only over ordinary temperatures, and the empirical formulæ based upon them being only strictly applicable to the interval covered by actual experiment, a reduction obtained by use of them for an interval between the red heat and melting point would be at best of doubtful value. I give, nevertheless, such a reduction, founded upon Matthiessen's* formula for the expansion of platinum between 0° C. and 200° C. This formula reads,

$$l = l_0 (1 + 0{\cdot}00000851\, t + 0{\cdot}0000000035\, t^2)$$

and the reductions are given in the following table:

TABLE X.

Platinum.	Celsius.
1900°	1294°
1800	1238
1700	1188
1600	1129
1500°	1081°
1400	1025
1300	968
1200	910

Of the accuracy of this comparison there are at present no means of deciding. Taking into consideration, however, the attempts already frequently made, to estimate the temperature of flames, glowing metal, etc., it seems likely that the above values, in degrees Celsius, are considerably too small.

Rosetti of Venice gives, for example, for the hottest portion of a Bunsen's burner flame, 1350°. According to Pouillet,† the melting points of various metals are as follows:

Wrought-iron 1600° C.
Steel .... 1400 C. 1300° C.
Cast-iron ..... 1200 C. 1050° C.
Gold (pure) .. 1200 C., etc.

Peekskill, N. Y., May 28, 1879.

ART. LVII.—*Notice of recent Additions to the Marine Fauna of the Eastern Coast of North America, No. 7*; by A. E. VERRILL. *Brief Contributions to Zoology from the Museum of Yale College.* No. XLIV.

AMONG the numerous additions recently made to the marine fauna of our coast by the fishermen of Gloucester, Mass., are two new species of Cephalopods. They both belong to the eight-armed division. One is a true *Octopus*. The other and more interesting one is the second known representative of the remarkable family of *Cirroteuthidæ*, characterized by the presence of a pair of fins, one on each side of the body, supported by a transverse cartilage; by the presence of a great web, surrounding and uniting all the arms, nearly to their tips; and by the presence of two slender cirri between the suckers, along the greater part of the length of the arms.

Our species differs so widely from *Cirroteuthis Mülleri* Esch., the only representative of the family hitherto described, that it is necessary to constitute for it a new genus.

Stauroteuthis, gen. nov.

Allied to *Cirroteuthis*, but with the mantle united to the head all around, and to the dorsal side of the slender siphon, which it surrounds like a close collar, leaving only a very narrow opening around the base of the siphon, laterally and ventrally.

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[*] Matthiessen, Phil. Mag., VI, vol. xxxii.

[†] Pouillet, Comptes Rendus, i, ii.

Fins triangular, in advance of the middle of the body. Dorsal cartilage forming a median angle directed backward. Body flattened, soft, bordered by a membrane. Eyes covered by the integument. Web not reaching the tips of the arms, the edge concave in the intervals. Suckers in one row. Cirri absent between the basal and terminal suckers. Right arm of second pair is altered, in the male, at the tip.

Stauroteuthis syrtensis, sp. nov.

♂. Head broad, depressed, not very distinct from the body. Eyes large. Body elongated, flattened, soft or gelatinous, widest in the middle, narrowed but little forward, but decidedly tapered, back of the fins, to the flat, obtuse, or subtruncate tail. The sides of the head and of the body, forward of the fins, are bordered by a thin soft membrane, about half an inch wide. The fins are elongated, triangular, obtusely pointed, placed in advance of the middle of the body. Siphon elongated, slender, round, with a small terminal opening. Mantle edge so contracted and thickened around its base as to show scarcely any opening, and united to it dorsally. Arms long, slender, subequal, each united to the great web by a broad membrane developed on its outer side, widest (about 1·5 inch) in the middle of the arm, while the edge of the web unites directly to the sides of the arms and runs along the free portion toward the very slender tip, as a border. This arrangement gives a swollen or campanulate form to the extended web. Edges of the web incurved between the arms, widest between the two lateral pairs of arms. The arms bear each fifty-five or more suckers, in a single row. Those in the middle region are wide apart (·5 inch or more) with a pair of slender, thread-like cirri, about 1 inch long, midway between them. The cirri commence, in a rudimentary form, between the 5th and 6th suckers, on the dorsal arms, and between the 7th and 8th, on the ventral ones. They cease before the 23d sucker on the dorsal and lateral arms, and before the 22d on the ventral ones. Near the mouth, and beyond the last cirri on the free portion of the arms, the suckers are more closely arranged. They are small, with a deep cavity. Color, in alcohol, generally pale with irregular mottlings and streaks of dull brownish; inner surface of arms and web, toward the base, and membrane around the mouth, deep purplish brown. Length from end of body to base of arms, 6·30 inches; length to posterior base of fins, 2·50; to anterior base, 4; width across fins, 5; in advance of fins, 2·70 (not including lateral membrane); across eyes, 1·75; across end of tail, 1·20; diameter of eye, 1; width of fins, at base, 1·20; their length, 1·75; length of arms, 13 to 14 inches; portion beyond web, 2·5 to 3 inches. Edge of extended web, between upper arms, about 4 inches; between lateral arms, about 8 inches; entire circumference of web, about 48 inches.

Taken by Capt. Melvin Gilpatrick and crew, schooner "Polar Wave," N. lat. 43° 54′; W. long. 58° 44′, on Banquereau, about 30 miles E. of Sable I., in 250 fathoms. Presented to the U. S. Fish Commission, Sept., 1879.

Octopus piscatorum, sp. nov.

Body of female is smooth, depressed, about as broad as long. Obtusely rounded posteriorly, not showing any lateral ridges, nor dorsal papillæ. No cirrus above the eyes. Arms long, rather slender, tapering to long, slender, acute tips, the upper ones a little (·1 of an inch) shorter than those of the second pair, which are the longest; the third pair are about one-half inch shorter than the second; the ventral pair about one-fourth inch shorter than the third. In our specimen all the arms on the right side are somewhat shorter than those on the left, and the web between the 1st and 2d arms is narrower, due perhaps to recovery from an injury. The suckers are moderately large, alternating in two regular rows, except close to the mouth, where a few stand nearly in a single line; about fourteen to sixteen are situated on the part of the arms included within the interbrachial web. The whole number of suckers on one arm is upwards of seventy. The web between the arms, except ventrally, is of about equal width, and scarcely more than one-fourth the length of the arms, measuring from the beak. Between the ventral arms the web is about half as wide as between the lateral.

Color of alcoholic specimen, deep purplish brown, due to very numerous crowded, minute, specks; eye-lids whitish. The front border of mantle, beneath, with base of siphon and adjacent parts, is white; end of siphon brown. Lower side of head and arms lighter than the dorsal side. Total length, from posterior end of body to tip of arms, of 1st pair, 6·20 inches; 2d pair, 6·30; 3d pair, 5·75; 4th pair, 5·25; to web between dorsal arms, 3·25; between ventral arms, 2·50; to edge of mantle, beneath, 1·20; to center of eye, 1·55. Breadth of body, 1·25; of head across eyes, 1·20; breadth of arms, at base, ·22; diameter of largest suckers, ·10; length of arms, beyond web, 1st pair, 3·00; 2d pair, 3·25; 3d pair, 2·80; 4th pair, 2·75.

Taken by Capt. John McInnis and crew of the schooner "M. H. Perkins," from the western part of Le Have Bank, off Nova Scotia, in 120 fathoms. Presented to the U. S. Fish Commission, Oct. 1879.

This species is easily distinguished from *O. Bairdii*, by its more elongated body, its much longer and more tapered arms, with shorter web; by the absence of the large, rough, pointed papilla, or cirrus, above the eyes, and by its general smoothness. The white color of the underside of the neck, siphon and mantle-border also appears to be characteristic.

ART. LVIII.—*Notes on the Geology of Galisteo Creek, New Mexico;* by JOHN J. STEVENSON, Professor of Geology in the University of the City of New York.

GALISTEO CREEK rises near the southern end of the Santa Fe mountains and flows southward for nearly fifteen miles to Galisteo; where, being increased by the Arroyo San Cristobal, coming from the east, it turns westward and flows in that direction to the Rio Grande. Its area is divided by a narrow dike, which forms a distinct ridge and separates the portion drained by the creek in its southward flow, from that drained by the Arroyo San Cristobal and the creek in its westward flow. These divisions may be distinguished as the upper and the lower area of the Galisteo. The region is not wholly unknown to geologists, for it has been visited by Dr. Newberry, Dr. Hayden and Professor Cope, whose views respecting the age of the coal beds and of the peculiar Galisteo sandstone are not in accord. The details of my observations there will be given in my report to Captain Wheeler; here, by consent of the Chief of the Engineer corps, U. S. A., a brief résumé of the results will be given, in so far as they bear upon the matters in dispute.

The shales of the Fort Pierre group (No. 4 of Mr. Meek's general section) are shown at barely sixteen miles below Galisteo dipping gently eastward in mesas on both sides of the creek. They have all the characteristic features of that group and yield its peculiar fossils at many localities. The Laramie group rests on them, and its western outcrop is reached on the south side of the creek at somewhat less than sixteen miles below Galisteo. There the rocks dip toward the east-northeast and at a low angle; this is the northern termination of an extensive area of Laramie, reaching southward for many miles and surrounding the Placer and Sandia mountains. The eastern outcrop of the Laramie beds passes rudely north and south through Galisteo, and there the dip is westward. The width of the area from east to west along the creek is not far from fifteen miles.

A detailed section of 440 feet, taken on the western outcrop, bears no resemblance in detail to sections from the same horizon in the Trinidad coal field, and correlation of the beds in the two fields is not possible. The coal beds in the Galisteo area are thin and variable, and little of economic interest exists aside from the anthracite beds, which contain coal altered by the influence of a gigantic dike passing between the Placer mountains and Galisteo creek. But there is much material of scientific interest, for the Laramie beds show an unexpected intimacy with the underlying Fort Pierre.

Passing the eastern outcrop of the Laramie, one comes at once to a wide park, lying mostly on the south side of the Arroyo San Cristobal and eroded amid the Colorado shales. The Fort Pierre sub-group occupies the western side of this park and, as usual, is much thicker than are the Niobrara and Fort Benton combined. Its shales show the ordinary features, for here are the lines of huge ferruginous concretions, of calcareous concretions, and the succession of dark, gray and yellow shales with abundance of selenite crystals. The concretions, except where showing a cone-in-cone structure, are full of fossils; enormous *Inocerami* with smaller species are common, *Ammonites*, *Baculites*, *Tachytriton*, *Aporrhais*, *Gyrodes*, *Fasciolaria* and *Ostrea* are abundant, all of them belonging to species occurring in the Fort Pierre group at other localities farther north.

Below the Fort Pierre are the bluish-gray argillaceous limestones of the Niobrara sub-group (Cretaceous No. 3) with the same physical features everywhere shown throughout the whole region south from Denver, and containing *Inoceramus problematicus* along with other species always regarded as characterizing this horizon. The exposures of this group are few but ample. An excellent exhibition can be seen at barely a mile southeast from Galisteo, where the limestone was quarried to be burned into lime. The dark brown shales of the Fort Benton (Cretaceous No. 2) are ill-exposed at the base of the Dakota mesa, which forms the eastern boundary of the park, south from the Arroyo.

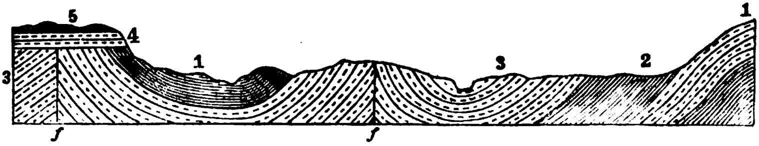
The Dakota is well exposed, the three provisional groups, which will be proposed in my report, being shown along the Arroyo San Cristobal. The Upper Dakota forms the mesa or east wall of the park and consists of light gray and yellow sandstones; the Middle Dakota consists of blue, white and red sandy to clayey shales, with a bed of limestone, a conglomerate of limestone and iron ore and streaks of gypsum; while the Lower Dakota, made up of gray and yellow sandstones like those of the Upper Dakota, reaches eastward and becomes the upper part of a great mesa, the southwest wall of the Pecos valley.

The succession in the lower Galisteo area is absolutely clear, showing the Dakota, Fort Benton, Niobrara, Fort Pierre and Laramie groups in their proper order. All of these dip westward until perhaps eight miles below Galisteo, where the dip is reversed so that the Laramie beds run out at sixteen miles below Galisteo and the Fort Pierre shales come again to the surface. Each of these groups is perfectly characterized and no difficulty is encountered in the attempt to identify them. The physical features and the fossils are not materially different from those found elsewhere in the same groups within the whole region south from Denver, except that *Halymenites major*, so common at the base of the Laramie group in the Trinidad coal field, is absent here. But impressions of dicotyledonous plants occur in the Galisteo region, which are closely allied to those found in the Trinidad coal field. The coal beds on the northeast slope of the Placer mountains are as clearly Laramie as are those of the Trinidad or the Cañon City coal field.

But the geology of the upper Galisteo area is far from being so simple as that observed along the south side of the creek within the lower area.

No reference has been made to the north side of the creek within the lower area; that can be considered more conveniently in connection with the upper area. A broad uneven park, designated on the Engineer map as the Arroyo de Los Angeles, opens into the lower area at perhaps five miles below Galisteo, and the dike, previously referred to, forms its southeast boundary for several miles.

If a section be carried across the area of the upper Galisteo near its southern edge, the conditions will be found such as are represented in the following diagram.



Cross Section on the Upper Galisteo.

1. Dakota. 2. Colorado. 3. Laramie. 4. Galisteo. 5. Alluvium.

The Upper Dakota sandstone is in the bluff on the east side, where the dip is very rapid; behind it are the shales and limestones of the Middle Dakota, and the sandstones of the Lower Dakota are shown still further east. Going westward toward Galisteo creek, one crosses the Dakota, the imperfectly exposed Fort Benton and Niobrara, the finely exposed Fort Pierre, and finally before reaching the creek, finds himself on the Laramie sandstones. Thus far the dip has been *westward;* but immediately beyond the creek, the dip is reversed, so that before the low insignificant roll, separating the Arroyo de los Angeles from the Galisteo, is reached, the Laramie rocks are dipping *eastward* and almost vertical, thus forming a synclinal.

But on the opposite side of this low divide, the Lower Dakota sandstones are exposed and dip westward at 65°; at but a little way further westward are the variegated shales and the limestone of the Middle Dakota. On the west side of the Arroyo, the Lower Dakota rocks are dipping very sharply eastward, so that here too a synclinal exists. Thus there are two faults, one following the divide between the Arroyo and the creek, while the other follows the west side of the Arroyo, whereby this fragment of Dakota has been thrust through the Laramie rocks. The two faults come together on the north side of lower Galisteo at the mouth of the Arroyo and the Dakota rocks do not cross the creek. The Colorado shales do not appear on either side of the faulted area.

But on the west side of this arroyo there appears a series, newer than any yet noticed. It covers the mesa stretching west and north from the Galisteo, and is continuous from the Santa Fe and Placer road on the lower Galisteo almost to the end of the Archean area on the upper Galisteo. This is the Galisteo group. As far as exposed within the area examined, which extends to but a little distance west and north from Galisteo creek, this group is

1. Breccia of trachyte...... 150 feet.
2. Soft, light gray sandstone.. 40 feet.

The breccia is well shown on the lower Galisteo from the Santa Fe and Old Placer road to the mouth of the Arroyo de los Angeles. It is exceedingly dark gray or even lead-colored and is composed altogether, where examined, of trachyte in angular fragments, cemented by finer material apparently of similar nature. This breccia was followed up the Arroyo to the Galisteo and Santa Fe road; but there it practically ends, and the evidence suggests that it was worn away by the erosion which produced the broad mesa. Its fragments litter the surface of that mesa. The thickness assigned this mass is that seen at the mouth of the Arroyo. It may be greater further toward the northwest.

The sandstone is very light gray, excessively soft and incoherent, so that it yields as readily to the weather as though it were loose sand, weathering indeed more freely than do the tough alluvial deposits along the creeks. This is the lowest bed of the group found within the area visited.

The relation of the Galisteo group to the underlying rocks is well shown at the head of the Arroyo, where the Dakota beds dip westward at 65°, while the lower sandstone of the Galisteo rests on their planed-off edges and dips in the same direction at less than one degree. A more curious illustration of the unconformability is shown immediately below the mouth of the Arroyo, where the breccia was deposited around a projecting wall of lower Dakota, which dips at nearly 60°; and the contrast in color is as great as that would be between a trachyte dike and a surrounding mass of basalt. Both the breccia and the underlying sandstone are exposed here and are conformable.

The Galisteo beds are not affected by the faults found in the Arroyo de los Angeles, whereas the Laramie beds are involved in them; the breccia is composed largely of trachyte from Los Cerillos, a group of hills, relics of dikes, shown on the north side of Galisteo creek at sixteen miles below the village. But the outburst of trachyte, forming those hills, caused frightful distortion of the Laramie beds. It is clear, then, that the Galisteo group can not be conformable to the Laramie. The former group does not cross the Galisteo creek at any point.

The lower sandstone of the Galisteo group was followed up the creek for more than seven miles above Galisteo, and its ashen color gives a strange appearance to the deeply eroded face of the mesa. The vertical yellow and almost white sandstones of the Lower Dakota yield readily to the weather and the debris from the light gray Galisteo sandstone mingles with that from these; so that, to one ascending the creek and following the line of the eastern fault, the Galisteo sandstone seems to be triple, white, yellow and gray, whereas the white and yellow belong to the Lower Dakota, on which the Galisteo sandstone rests unconformably.

The coal beds of the Placer mountains, occupying the plateau between those mountains and Galisteo creek are synchronous with those of the Trinidad coal field and belong to what is known as the Laramie group, which, however, is synonymous, in part at least, with Fox Hills.

The Galisteo group rests unconformably on the Laramie and Dakota; and contains a great bed composed wholly of the later lavas; it is therefore Tertiary.

Art. LIX.—*Short Notes upon the Geology of Catoosa County, Georgia;* by A. W. Vogdes, U. S. Army.

A SHORT distance west of Catoosa Station, on the Western and Atlantic Railroad, we find a small cut which exposes the rocks of the Niagara period. This formation is composed in descending of the following strata:

1. Thin bed of limestone made up of crinoidal joints.
2. Cherty bed containing the columns of *Caryocrinus.*
3. Shaley beds with concretions.
4. Black slate containing about fifty per cent of bituminous matter.

This outcrop in the valley of the Chickamauga is not over ten feet in thickness and dips about twenty-five degrees to the east. A few hundred yards to the west along the river bank, the topography of the country becomes more hilly, and the railroad passes through a cut of about 100 feet. On the map of the county this is known as section 28, lot no. 204, or Taylor's Ridge. This section exposes an outcropping formation of the Upper Silurian Age which belongs to the Clinton

Epoch. The upper beds are thin and composed of an arenaceous limestone, containing fragments of Crinoids and shells more or less wave-broken, as if this stratum marked the line of the Clinton sea. Immediately beneath the limestone we find a laminated sandy bed intermixed with sandstone of different degrees of hardness, which is well exposed in the railroad cut and along the banks of the Chickamauga River. The total thickness of these beds is about 150 feet, the strata having a general dip 15° east.

The geological formation of Taylor's Ridge is more clearly defined with regard to the Upper Silurian age about ten miles southeast from Catoosa station, at Dug Gap in Whitfield county. This section exhibits the Lower Silurian black shales outcropping along the base of the gap, dipping about twenty-five degrees to the east, and known in Dalton as the "coal beds;" immediately above these shales the Medina sandstones appear or a sandstone which stratigraphically may be assigned to this group; as far as examined it contains no fossils. Superimposed upon these sandstones along the second bench of the Gap we find the Clinton, which is composed in descending order of the following strata:

1. Arenaceous layers and sandstone.
2. Hematitic layers containing *Calymene Clintoni*, *C. rostrata*, and generally trilobitic.
3. Arenaceous shales.
4. Sandstone containing *Streptorhynchus subplana*.
5. Hard sandstone containing hematite.
6. Light sandy beds of the Medina.

The best section examined is about twenty feet in thickness, but the measured thickness of the Clinton gives about 150 feet.

In order to illustrate the true geological sequence of Taylor's Ridge it is necessary to trace the different rocks from Atlanta to Ringgold, but at present we will simply give the section at Ringgold, which is about four miles to the west of our first section, taken near Catoosa station. The town of Ringgold is located in a valley composed of the Trenton limestone. This group is highly fossiliferous; it has a northwest and southeast strike, dips fifteen degrees to the east, being composed of a flinty rock, underlaid by a chocolate-colored shale, which is generally denuded; these shales are underlaid by a blue limestone of over three hundred feet in thickness. Superimposed and forming the hills is a great mass of red laminated sandstone of the Hudson River group. These sandstones are about five hundred feet in thickness, dip nineteen degrees east, one mile east of Ringgold in the gap, and contain only a few specimens of *Orthis testudinaria*.

Between Ringgold and Catoosa Station the Chickamauga river divides the ridge; the hills to the northwest are called Oak Mountains, and those on the southeast Taylor's Ridge. After passing through this gap the eastern exposure of these hills shows the overlying Medina, Clinton and Niagara groups.

The paleontological characteristics of this outcropping stratum of the Upper Silurian periods are interesting, especially the fossils of the upper beds. These fossils are poorly preserved and consist generally of casts. From our collection we have been enabled to indentify the following species:

Calymene Clintoni Hall; *Cryptonymus* (*Encrinurns*) *ornatus* Hall and Whitfield; *Cryptonymus* (*Encrinurus*), *Illænus*, *Proetus; Leperditia*, sp., having the right valve marginated by a furrow, except along the dorsal edge, as in *L. marginata ; Othis elegantulo*, a species common to the Clinton and Niagara group; *Chœtetes lycoperdon*, cast from the lower beds; *Zaphrentis bilateralis?*, broken specimens from the upper bed; *Conularia*, sp.?

Of the *Cryptonymus ornatus* we have in our collection two pygidia which we have assigned to this species, although the casts do not show the nodes ornamenting the axis and pleuræ. The specimens compare otherwise with Professor Hall's type given in Palæontology of New York, vol. ii, pl. lxvi*a*, fig. 1*a*. Vertical distribution Clinton group.

There is also a new trilobite, *Calymene rostrata* Vodges, from the upper arenaceous limestone beds of the Clinton group, Catoosa Station, Georgia, which will be fully described hereafter. It differs from all other species of this genus in having a distinct projecting process in front of the glabella. The facial lines cut the anterior border at the apex, giving to the frontal limb a triangular form; at their juncture the marginal border is raised and forms the triangular process which supports the projection.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On Electrolysis with Alternating Currents.*—Supposing that certain chemical transformations in the living organism are due, not to reduction or oxidation alone, but to both combined, **Drechsel** has devised a method for subjecting a liquid to reduction and oxidation in rapidly alternating succession. For this purpose, the electrodes of a Grove battery of 4 to 6 cells are placed in the solution, an automatic commutator being included in the circuit, so as to reverse the current rapidly. Each electrode thus becomes alternately positive and negative, first oxygen and then hydrogen being alternately evolved on its surface in the nascent state, each exerting its special action upon the dissolved substance. The

first solution experimented with was one of ammonium carbonate, the same as is used as a reagent. The electrodes were of platinum. Gas was actively evolved, the temperature rose, and after eight hours the experiment was interrupted and the liquid was evaporated on the water-bath. From it a salt crystallized out in beautiful white needles. On analysis it was found to contain 64·69 per cent of platinum and was evidently a salt of a platinum base. The small quantity prevented complete investigation; though its solution gave with concentrated hydrochloric acid a bright green and with nitric acid a sky-blue crystalline precipitate. The electrodes lost in ten hours 0·1 gram; while when the electrolysis was conducted with a continuous current in the ordinary way, no platinum at all could be detected in the solution and at most only 0·002 gram had been transported from the anode to the cathode. On repeating the experiment with a less rapid alternation of the current, the liquid became warm, but gave no precipitate; on cooling it, however, during the experiment, an abundant crystalline precipitate was formed, which though also a salt of a platinum base, contained only 38·6 per cent of platinum, and gave with hydrochloric acid, not a green but a colorless crystalline powder consisting of microscopic needles. Finally, a solution of grape sugar mixed with sodium phosphate was submitted to alternating electrolysis, using platinum electrodes of large size, contact being prevented by a disk of filter paper between them. At the close of the experiment, there was formed on the platinum, at the place where the paper had rested against it, a brownish, transparent crust, easily separated into plates, and which left on combustion a considerable amount of platinum. The author is continuing his experiments upon this new method.

In a note to this paper, KOLBE says that the highly interesting observations of Drechsel raise the question of the behavior of salts and salt-solutions of inorganic and organic acids in presence of powerful and alternating voltaic currents; as, for example, whether an aqueous solution of potassium acetate suffers decomposition without accompanying oxidation. Since Drechsel does not purpose to extend his studies in this direction, Kolbe intends to examine the action of a series of salts under these conditions.—*J. pr. Ch.*, xx, 378, Oct., 1879. G. F. B.

2. *On the Basicity of Dithionic or Hyposulphuric Acid.*—It has been generally assumed that hyposulphuric acid is dibasic and hence that its formula is $H_2S_2O_6$. KOLBE has written it in his Lehrbuch $\left\{\begin{matrix}SO_2OH\\SO_2OH\end{matrix}\right.$ or di-sulphoxyl, as oxalic acid is $\left\{\begin{matrix}COOH\\COOH\end{matrix}\right.$ or di-carboxyl. If this view be true, hyposulphuric acid should form, not only normal salts, but also acid, and mixed salts. Kolbe has set several of his students at work to endeavor to form either an acid salt or a mixed salt, an ether acid or an amic acid, of hyposulphuric acid, but without effect. Since all these bodies are readily given by oxalic acid, Kolbe comes to the conclusion that hyposulphuric acid is monobasic and contains but one hydroxyl

group. Hence the formula of it should be HSO_2 or $(SO_2)OH$. The importance of this conclusion lies in this, that, if it be conceded, the equivalence of sulphur is five in this compound and it becomes a perissad instead of an artiad as it is in all other combinations.—*J. pr. Ch.*, xix, 485, June, 1879. G. F. B.

3. *On the Non-existence of Pentathionic acid.*—In the hope of converting the polythionic acids into a new series of sulphur acids poorer in oxygen, SPRING submitted them to the action of sodium amalgam. But instead of the result expected a very different one was obtained. The sodium inserted itself between the sulphur atoms, splitting the molecule into two simpler ones; just as oxalic acid is converted by hydrogen into formic acid. For example, with tetrathionate, $KO_3SS.SSO_3K+Na_2=KO_3SSNa+NaSSO_3K$; with trithionate, $KO_3S.SSO_3K+Na_2=KO_3SNa+NaSSO_3K$; with dithionate $KO_3S.SO_3K+Na_2=KO_3SNa+NaSO_3K$. Precisely as $HO_2C.CO_2H+H_2=HO_2C.H+H.CO_2H$. In order to test this reaction in the case of pentathionic acid, the author attempted the preparation of this body; but after five months of work he was unable to obtain it. This result raised the question of the existence of this acid. All attempts to prepare it, by the method either of Wackenroder or of Fordos and Gelis resulted only in the production of tetrathionic acid. The action of hydrogen sulphide upon sulphurous oxide in aqueous solution produces hyposulphurous acid; and this is oxidized as it is formed into tetrathionic acid by the sulphurous acid present, the hydrosulphurous acid of Schutzenberger being formed at the same time. Pentathionic acid, therefore, appears to be as yet unknown.—*Liebig's Ann.*, cxcix, 97, Oct., 1879. G. F. B.

4. *On the Atomic Weight of Tellurium.*—WILLS has undertaken a re-determination of the atomic weight of tellurium, in order to ascertain whether the value of this constant as at present accepted from the experiments of Berzelius and von Hauer, or the value assumed for it in Mendelejeff's classification, is the more correct. The crude tellurium was purified by fusion with sodium carbonate and sulphur, the fusion extracted with boiling water, the filtrate acidulated with acetic acid, the precipitate well washed, oxidized with nitric acid, evaporated to dryness, heated with hydrochloric acid, the tellurium precipitated by sodium sulphite, washed, dried, fused with potassium cyanide, the fusion treated with water and the deep-claret solution exposed to the air in a flask when the tellurium separates in long needle-shaped crystals. After washing and careful drying these were distilled in a current of hydrogen. The distilled water, nitric and hydrochloric acid used were carefully purified and the accuracy of the weights and balance employed verified. On oxidizing the tellurium with nitric acid, and calculating the atomic weight from the TeO_2 obtained, the mean of five experiments gave 127·8 with a probable error of 0·32. Four experiments on oxidation with equa regia gave 127·907 with a probable error of 0·053. Five determinations by von Hauer's method, of the bromine in the compound K_2TeBr_6, gave Te =

126·83 with a probable error of 0·198. Hence the atomic weight of tellurium is essentially that obtained by Berzelius and von Hauer, and is higher than that of iodine, after which in Mendelejeff's system it should be placed, instead of between iodine and antimony.—*J. Ch. Soc.*, xxxv, 704, Oct., 1879. G. F. B.

5. *On the Preparation of Propylene glycol from Glycerin.*—A very convenient method has been proposed by **Belohoubek**, for the direct preparation of propylene-glycol from glycerin. When glycerin is mixed with sodium amalgam in the proportion of one molecule of glycerine to one atom of sodium, and gradually warmed, a gummy mass results which, according to Letts, consists chiefly of monosodium glycerate. On submitting this to distillation, water and gas are at first evolved, then there comes over a colorless liquid readily miscible with water, and a brown strongly smelling liquid, lighter than water. The colorless liquid fractionated gave a product boiling at 186°–188°, having a weak odor like allyl, a burning taste, removable by agitation with ether, and on analysis the formula of propylene glycol. Its specific gravity at 0° C., was 1·054, its vapor density 2·68. With hydrochloric acid, it formed a chlorhydrin, which by the action of caustic potash gave propylene oxide. The yield was about 16 per cent of that required by theory. That the action here is due to the sodium of hydrate formed, was proved by distilling equal molecules sodium hydrate and glycerin. Nine per cent of the theoretical yield was obtained.—*Ber. Berl. Chem. Ges.*, xii, 1872, Oct., 1879. G. F. B.

6. *On Skatol.*—In his researches on the volatile substances contained in human feces, **Brieger** isolated a series of bodies belonging, some to the fatty and others to the aromatic class. The principal aromatic product of the decomposition of albumen in the intestinal canal, is a substance resembling indol to which he has assigned the name skatol. It crystallizes in brilliant white plates and posesses an intense fecal odor. It fuses at 93·5°, and is difficultly soluble in water. Warmed with dilute hydrochloric or nitric acid, it gives a violet color. Analysis gives it the formula C_9H_9N, its vapor density being 65·2. Blood-albumen, digested with pancreas and water at 36° C. for six to ten days, yields skatol on distillation. Two and a half kilograms albumen gave one gram of skatol.—*Ber. Berl. Chem. Ges.*, xii, 1985, Oct., 1879.
G. F. B.

7. *On the Synthesis of Lactose.*—**Demole** has succeeded in effecting a partial synthesis of milk-sugar, accomplishing an important step toward its complete synthetical production. Starting from the octacetyl-diglucose of Schutzenberger, which is isomeric and not identical with octacetyl-saccharose, the author, assuming that the glucose molecules of both saccharose and lactose are different, sought, by combining levulose and dextrose to produce saccharose and by uniting galactose with lactoglucose to produce lactose. Comparing octacetyl-diglucose with octacetyl-saccharose, they were found to have some points of difference, in solubility,

in rotatory power, and in their reactions, the former yielding di-glucose, the latter cane-sugar. By the action of dilute acids upon lactose, two isomeric bodies, galactose and lactoglucose are produced. After removal of the acid, the product of this reaction was evaporated and carefully dried. It had all the properties of a mixture. It was mixed with three parts of acetic oxide, and heated to boiling until complete solution resulted. On treatment with water, a gelatinous ether resulted having the properties of octacetyl-lactose. On saponification by pouring the alcoholic solution of the synthesized ether into baryta water at 90°, and heating, there was obtained, on neutralizing and evaporating to dryness, and recrystallizing, a substance having all the properties of lactose, crystallizing in the orthorhombic system, and having a rotation $(\alpha)_D = +56{\cdot}7^\circ$. On heating to 140°–145°, it afforded an anhydride.—*Ber. Berl. Chem. Ges.*, xii, 1935, Oct., 1879.

G. F. B.

II. GEOLOGY AND NATURAL HISTORY.

1. *Report of the Geological Survey of Canada*, for 1877–78, ALFRED R. C. SELWYN, Director. 8vo. Montreal, 1879. (Dawson Brothers).—This volume contains a wide range of geological observations, and is a very valuable contribution to the science. It includes a Report on the Quebec group by Mr. SELWYN; on Southern British Columbia (173 pages) by G. M. DAWSON; with an Appendix on the Fossil Insects, by S. H. SCUDDER, and on Tertiary plants, by Dr. DAWSON; on the East coast of Hudson Bay, and on the country between this Bay and Lake Winnepeg, by R. BELL; on New Brunswick Geology, by R. W. ELLS, L. W. BAILEY, and G. F. MATHEW; on Cape Breton, N. S., by H. FLETCHER; on minerals of the Apatite-bearing veins of Ottawa, with notes on miscellaneous rocks and minerals, by B. J. HARRINGTON; on Canadian Apatite, by C. HOFFMANN; and is illustrated by many sketches, sections and maps.

Mr. Selwyn divides the Quebec series of Logan into three groups: "(1.) The Lower Silurian group," containing fossils; "(2.) The Volcanic group, probably Lower Cambrian." "(3.) The Crystalline Schist group (Huronian ?)." The evidence of a general volcanic origin of the second group is not stated. The kinds of rocks mentioned:—"thick-bedded feldspathic, chloritic, epidotic and quartzose sandstones, red, gray and greenish siliceous slates and argillites, great masses of dioritic, epidotic and serpentinous breccias and agglomerates, diorites, dolerites, and amygdaloids holding copper ores, serpentinous felsites, and some fine-grained granitic and gneissic rocks, also crystalline dolomites and calcites," make a remarkable assemblage to be spoken of as "these volcanic rocks." They were, for the most part, included in the Sillery sandstone formation by Logan. The account of the Quebec group is followed by the statement that, "in view of the usual associations of Labrador feldspars," (referring here to their occurring as a constituent of some igneous rocks) "the labradorite or anorthosite" rocks of the Adirondacks and British America, probably "represent the *volcanic* and intrusive rocks of the Laurentian period."

These conclusions as to volcanic rocks make the mineral labradorite, and some others, settle a great question that should be settled by geological investigation; for we rightly ask that volcanic origin should be proved by the presence of obvious volcanic or eruptive conditions. What there is in a lime-and-soda feldspar to make its presence proof of eruptive origin, or of the existence of great volcanoes in a region that shows no other evidence of it, no one has pointed out. Lime is an exceedingly common material in sediments; and soda or sodium is present in other feldspars, and, in the state of chloride, abounds in sea water and occurs in salines and beds of rock-salt in strata of various ages. Moreover, the mineral labradorite, certainly does occur as a chief constituent in some metamorphic rocks that have nothing of volcanic origin in their constitution, as the writer has shown to be true in the vicinity of New Haven, Connecticut. So with felsyte, a rock made up of common feldspar or orthoclase, with often quartz—its composition is not sufficient evidence of an igneous or volcanic-ash origin. Announcements on such evidence, of the former existence of volcanoes in a region, belong, in the writer's view, only to fancy-sketches.

The rocks of Mr. Selwyn's volcanic series were, for the most part, pronounced metamorphic by Logan, one of the best of geologists; and the list above given seems to show that Logan was, in all probability, right in this respect, whatever may be the fact as to the relative position of the Sillery sandstone and the fossiliferous beds of the Quebec group. The facts afforded by the Green Mountain region to the south in Vermont and Massachusetts, brought out by Mr. Wing and the writer, bear on the latter question.

In the course of Mr. Selwyn's paper on the Quebec group, he makes the just remark: that the names Norian, Montalban, Taconian and Keweenian, "applied to pre-Cambrian formations," serve no useful purpose; these representing "simply groups of strata which occupy the same geological interval and present no greater differences in their physical and mineralogical characters than are commonly observed to occur in formations of the same epoch in widely separated regions." "No better instances of such difference could be cited than the Mesozoic and Carboniferous formations of British Columbia, and those of the same periods in Eastern America and the Silurian and Cambrian formations of Australia, Europe and America."

Mr. G. M. Dawson's report contains a large amount of important information, both geological and economical. With regard to the drift of the interior of Columbia, he says that glacial markings occur up to a height of 5,280 feet on Iron Mountain; that, in the early part of the Glacial era, a great glacier, confluent with that of the coast, covered probably the interior of the Province, which may have been 2,000 feet thick; that the regions of greatest precipitation and height of the ice was north of the 54th parallel; that it is "highly probable" that that part of the Pacific coast stood at an elevation greater than at present in times immediately preceding the Glacial, and "may have retained this altitude" during the era of the great confluent glacier. He adds, with an expressed questioning, "If I am right in attributing the flooding of the interior to the sea, we find a rapid subsidence of the land coincident with the decay of these vast glaciers;" and then speaks of a *second* short advance of the glaciers on the plateau from the mountains. No evidence of the presence of the sea in fossils or other decisive facts is presented.

Mr. R. Bell states, that on the east coast of Hudson Bay there is "abundant evidence that the sea-level is falling at a comparatively rapid rate;" that since the Posts of the Hudson Bay Company were established at the mouths of the various rivers, there has been an increasing difficulty in approaching them with large craft; that it amounts probably to between 5 and 10 feet a century. Mr. Bell states that this sinking is apparent also on the west coast of the bay at the mouth of the Nelson and Haye's Rivers; that an island, "Mile Lands," now several feet above high tide, was, "within the recollection of the generation preceding the present one, submerged at high tide." About the beginning of the present century vessels ventured in Ten-shilling Creek, which could not now approach its mouth. To the north of Lake Winnipeg, a region of lakes, the glacial scratches in general run southwestward, and the direction is mostly between S. 35° W. and S. 55° W.

The reports on New Brunswick have great interest from the relation of the rocks to those of Maine, and Mr. Mathew's, on the superficial geology of the Province, gives long lists of courses of glacial striæ, as well as other information respecting the Quaternary. These, and the following reports, contain much that would be cited here if space allowed. J. D. D.

2. *The Geological and Natural History Survey of Minnesota*, under N. H. WINCHELL, State Geologist. *7th Annual Report for the year* 1878. 123 pages, 8vo. Minneapolis, 1879.—The report contains a statement as to the work of the year, made brief in accordance with the action of the Board of Regents, which has ordered also that the survey be substantially completed in four years, and be followed by the publication of a Final Report of two volumes, one on the Northern part of the State, and the other on the Southern. The chief part of the volume is occupied with a paper by C. L. Herrick, on the Entomostraca of the State, which is illustrated by 20 plates. The writer recommended the publication of this paper as the report states; but he does not vouch for the correct determination of all the species. J. D. D.

3. *Brief Notices of some recently described Minerals.—Eggonite.* Observed by Schrauf in minute crystals, of a light brown color,

implanted upon crystals of calamine from Altenberg, near Aachen. The crystals bear some resemblance to certain simple forms of barite, but are in fact triclinic, though with a pseudo-monoclinic symmetry due to twinning. H.=4–5. In composition probably a silicate containing cadmium.—(*Zeitsch. Kryst.*, iii, 352).

Herrengrundite. Described by Brezina as a basic copper sulphate. It occurs in six-sided tabular crystals, belonging to the monoclinic (or triclinic) system, with perfect basal cleavage. H. = 2·5. Color dark emerald green. Associated with gypsum, malachite and calcite from Herrengrund (Urvölgy), Hungary (Zeitsch. Kryst., iii, 359). The same mineral was described about the same time by Szabó (Tsch. Min. Mitth., ii, 311) under the name Urvölgyite. He differs from Brezina in making the lime afforded by the analysis an essential constitutent of the mineral, while the latter regarded it as being due to the presence of gypsum.

Hofmannite. Occurs in colorless, tasteless, tabular crystals in lignite. Composition given by the formula $C_{20}H_{36}O$. Described by Bechi (Pisa).

Leucomanganite. A foliated and radiated snow-white mineral. Colorless in thin plates, but before the blowpipe becomes brownish-black and fuses easily. Chemical composition unknown; contains protoxides of iron and manganese, alkalies and water.—(*Sandberger, Jahrb. Min.*, 1879, 370.)

Louisite. A leek-green, translucent, vitreous mineral; brittle with splintery fracture. H. = 6·5. G. = 2·41. Gelatinizes in hydrochloric acid. An analysis by H. Louis afforded:

SiO_2	Al_2O_3	FeO	MnO	CaO	MgO	Na_2O	K_2O	H_2O
63·74	0·57	1·25	tr	17·27	0·38	0·08	3·38	12·96=99·63

From Blomidon, N. S.; named by D. Honeyman.

Reinite. A blackish-brown, opaque mineral, with sub-metallic luster. Observed in large crystals belonging to the tetragonal system. The composition is expressed by the formula $FeWO_4$. Discovered by Professor Rein in Kimbosan in Kei, Japan, named by K. v. Fritsch and described by Luedecke.—(*Jahrb. Min.*, 1879, 286.)

Plagiocitrite, Clinophœite, Wattevillite, Clinocrocite: Hydrous sulphates described by S. Singer as being identified by him at the Bauersberg, near Bischofsheim.

Bhreckite (Vreckite), *Xantholite, Abriachanite:* Names given provisionally by Heddle to substances "which may prove to be new Scottish minerals." Bhreckite is a chlorite-like mineral; xantholite has nearly the composition of staurolite, but is thought to be monoclinic in crystallization; abriachanite is an impure, bluish clay-like mineral.—(*Min. Mag.*, iii, 57, 1879.)

Haughtonite is, according to Heddle, a new mica. It has a jet black color, in thin plates transmitting a dark brown light. G. = 3·03. An analysis of material from hornblendic gneiss of Roneval afforded:

SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O
37·16	15·01	7·69	17·35	1·04	8·88	1·13	1·60	8·18	2·12=100·16

Analyses of a similar mica from other localities afforded results agreeing more or less closely with the above. Its claim for recognition as a species distinct from biotite and lepidomelane rests chiefly upon the relative proportion of the two oxides of iron.

4. *Ueber den Boracit* von H. BAUMHAUER.—Through an investigation of the etching figures produced on crystals of boracite by a dilute mixture of hydrochloric and sulphuric acids, Baumhauer has proved that the species belongs to the orthorhombic system. This conclusion was earlier reached by Mallard, but Baumhauer explains the occurring forms by a somewhat different and more simple method of twinning. The method of investigation employed is one which he has done much to develop, and which he has successfully applied to the solution of other similar problems.—(*Zeitsch. Kryst.*, iii, 337.)

5. *Genaue Messungen der Epidot-Krystalle aus der Knappenwand im oberen Sulzbachthal* von N. VON KOKSCHAROW, Sohn.—The already very extensive series of monographs devoted to the crystallization of epidote has been recently enlarged by an important memoir by N. von Kokscharow, the son of the great Russian mineralogist. This memoir contains the result of a large amount of careful work, including the measurement and calculation of the important angles of the occurring forms. The axial ratio and angle of inclination for the species are determined with a high degree of exactness that leaves nothing to be desired.

6. *Canadian Apatite;* by CHRISTIAN HOFFMANN (Geological Survey of Canada).—Mr. Hoffmann has analyzed a series of Canadian apatites; he shows that they all belong to the class of fluor-apatites containing but a very small amount of chlorine. They are in general very free from impurity, as oxide of iron.

7. *Eucalyptographia: A Descriptive Atlas of the Eucalypts of Australia and the adjoining Islands;* by Baron FERDINAND VON MUELLER, K.C.M.G., F.R.S., etc. Decades 1 and 2, 4to, 1879. Melbourne and London. (Trübner, &c.).—It was a happy thought of the noted Australian botanist to describe anew and illustrate the species of *Eucalyptus,*—a thought long entertained, we are told, and at length undertaken under the patronage of the Victorian Government, and under conditions which promise success. For, in a country in which trees are of inestimable value, this genus comprises the principal timber-vegetation and is rich in other industrial products, while the species are very numerous, of very different economical importance and use, and almost throughout they are of difficult botanical limitation. Then Eucalyptus-trees are the sole rivals of the *Sequoias* of California in grandeur, appear in some cases to surpass them in height, and certainly exceed them in rapidity of growth. For the task in hand, even if economical considerations alone are taken into account, the indefatigable editor will certainly need, and ought freely to command, all the aids which can be afforded; but he complains, in the preface, that indispensable auxiliaries which he formerly controlled, have been withdrawn from the Government Botanist's department.

The complaint has reference to laboratory accommodation for technological investigation, and to the author's separation from the Botanic Garden, containing a large collection of growing trees which he had laboriously brought together. *Per contra*, let him consider how much valuable time he saves for true botanical work by his riddance from the multifarious cares which garden-superintendence involves.

In a work of this kind, which must needs take several years to finish, during which new species are sure to be discovered, and new information respecting the old ones is sure to come to light, the only practicable course is to bring out the illustrations without regard to scientific order, leaving them to be collected and systematically arranged at the completion of the undertaking. Consequently the figures and the letter-press are neither paged nor numbered. Both are in quarto form, a leaf (and commonly the whole of its two pages), as also a well-filled plate, being devoted to each species. The plates are well drawn, executed in good lithography, and contain fair dissections and not a little of microscopical detail. Some extra plates are given in illustration of the structure of the wood, and also of the anthers. To figure all the *Eucalypti* will require fourteen or fifteen decades; even then the work will be comparatively low-priced, for the decades are published at five shillings each. The book will have an interest beyond Australia, in all climates in which the cultivation of these trees may be hopefully attempted, such, for instance, as the south-western part of California. Indeed the mountain species might be tried on any part of our western coast, and some might be expected to withstand the occasionally severe cold of the districts bordering the Gulf of Mexico. A. G.

8. *Monographiæ Phanerogamarum Prodromi, nunc Continuatio, nunc Revisio* auctoribus ALPHONSO et CASIMIR DECANDOLLE. Vol. II, *Araceæ* auctore ENGLER. Paris: Masson, Sept., 1879. pp. 681.—This second volume of the supplement to the Prodromus is completely occupied by Dr. A. Engler, now Professor at Kiel, with his monograph of the order *Araceæ*. This great order Engler accepts in the largest sense, including the "*Pistioideæ*" (of *Pistia* only reduced to a single species), and the "*Lemnoideæ*" (*Spirodela*, *Lemna*, *and Wolffia*), these being ranked as the ninth and tenth sub-families of the order. The larger of the other sub-families divide into tribes and sub-tribes, and the genera are one hundred and one! A condensed account of the structure, distribution, and taxonomy of Araceous plants precedes the systematic portion, and a full index follows. There are no figures; but the author has illustrated the Brazilian species in the Flora Brasiliensis, and the structure and classification in the Acta of the Acad. Nat. Curiosorum. The genera and species of *Lemnaceæ* or *Lemneæ* (names surely to be preferred to "*Lemnoideæ*") are omitted, being the subject of a recent monograph by Hegelmaier. Under the habitat the country is cited, and then the specimens which have come under the author's observation, with their source. A. G.

9. *Anatomie Comparée des Feuilles chez quelques Familles de Dicotylédones;* par M. CASIMIR DECONDOLLE. A memoir separately issued from the *Mem. Soc. Phys.* and *Hist. Nat. de Genève*, tome xxvii, partie 2. 1879. pp. 427–480, and two plates, 4to.—One of Cassimir DeCandolle's earliest studies was into the structure and relations of the fibro-vascular elements of the leaf, and the results and deductions were brought out in his brief article entitled Theorie de la Feuille, in the year 1858. The present paper is in no respect theoretical, nor does it investigate the minute anatomy and formation of the vascular bundles. But it presents a comparative view of the general structure of the woody system of the petiole and principal veins in a very considerable number of Dicotyledons, mainly trees, and belonging to different natural orders. In this way the nature of the principal differences from species to species, and from one order to another, are brought to view, and the taxonomical value of such characters indicated. It is found that different species of the same genus sometimes accord, but sometimes differ notably in this part of their anatomy. Wherefore the classificatory importance of these differences is low, yet they may often be turned to good account in the discrimination of related species. The essential fibro-vascular system of the petiole, as displayed on a cross-section, forms either a closed ring or an arc open superiorly between the outer or cortical and the inner or medullary tissue; in the first case it is said to be closed or complete, in the second open or incomplete. Very commonly this is the only vascular system of the petiole, ribs, or veins. Not rarely there are additional or accessory bundles, sometimes external to the essential system, or *intracortical;* sometimes within the arc or ring, or *intramedullary;* occasionally there are both intracortical and intramedullary bundles. Generally plants of the same order will agree, at least approximately, in having the closed or open system, and in having or wanting the accessory bundles without or within. But, while *Acer Pseudo-platanus* has a well developed intramedullary cord, *A. platánoides* has none, and in general the Maples are divided in this respect quite independent of other characters; and the difference is similar and equally marked between the species of *Æsculus.* The oaks, which have been made a special study in this regard, appear to be somewhat equally divided between species provided with and those destitute of intramedullary bundles; but related species generally belong to the same category, yet not always. For in one case two species, of doubtful distinction until now, are confirmed by the discovery of an anatomical difference of this sort. All the Birches examined want the intracortical bundles and the principal system forms an open arc, and one or two Alders nearly agree with them; while the others have a closed ring and are furnished with intracortical bundles. The two plates contain about thirty accurately drawn and carefully engraved figures of sections, moderately magnified. A. G.

10. *Bentham and Hooker's Genera Plantarum.*—It is known to Botanists generally that the first part of the third (and concluding)

volume of this important work is passing through the press. We are informed that this part, which will complete the *Dicotyledones*, will be published in London at the close of the year. It is known to many of his correspondents that the present writer has arranged, by taking a considerable number of copies to secure this work for American botanists, or the public libraries with which some of them are connected, at a reduced price. As his own lists of those who have hitherto received the work through his mediation may not be complete, all those who wish to obtain the new part in this way are requested to communicate with him upon the subject without delay. A. G.

11. *Chesapeake Zoological Laboratory; Johns Hopkins University*, Baltimore, Md. *Scientific Results of the Session* of 1878 (June 24th to August 19th.) 170 pp. 8vo, with 13 plates. Baltimore: 1879.—This volume, issued under the auspices of the Johns Hopkins University, contains, besides lists of land plants and animals found at Fort Wool, the following important zoological papers: Development of Lingula, Development of Gasteropods, and Development of Squilla, with 12 plates, by W. K. Brooks; *Lucifer typus*, by W. Faxon, with 1 plate; and Early stages of Amphioxus, by H. J. Rice, with 2 plates.

III. ASTRONOMY.

1. *The Minor Planets, arranged in the order of their numbers;* by AARON N. SKINNER. (Communication to the Editors, dated Naval Observatory, Washington, October 4.)

No.	Name.	Discoverer.	Disc. No.	No.	Name.	Discoverer.	Disc. No.
1	Ceres	Piazzi		20	Massalia	DeGasparis	6
2	Pallas	Olbers	1	21	Lutetia	Goldschmidt	1
3	Juno	Harding		22	Calliope	Hind	7
4	Vesta	Olbers	2	23	Thalia	Hind	8
5	Astræa	Hencke	1	24	Themis	DeGasparis	7
6	Hebe	Hencke	2	25	Phocæa	Chacornac	1
7	Iris	Hind	1	26	Proserpina	Luther	2
8	Flora	Hind	2	27	Euterpe	Hind	9
9	Metis	Graham		28	Bellona	Luther	3
10	Hygeia	DeGasparis	1	29	Amphitrite	Marth	
11	Parthenope	DeGasparis	2	30	Urania	Hind	10
12	Victoria	Hind	3	31	Euphrosyne	Ferguson	1
13	Egeria	DeGasparis	3	32	Pomona	Goldschmidt	2
14	Irene	Hind	4	33	Polyhymnia	Chacornac	2
15	Eunomia	DeGasparis	4	34	Circe	Chacornac	3
16	Psyche	DeGasparis	5	35	Leucothea	Luther	4
17	Thetis	Luther	1	36	Atalante	Goldschmidt	3
18	Melpomene	Hind	5	37	Fides	Luther	5
19	Fortuna	Hind	6	38	Leda	Chacornac	4

No.	Name.	Discoverer.	Disc. No.
39	Lætitia	Chacornac	5
40	Harmonia	Goldschmidt	4
41	Daphne	Goldschmidt	5
42	Isis	Pogson	1
43	Ariadne	Pogson	2
44	Nysa	Goldschmidt	6
45	Eugenia	Goldschmidt	7
46	Hestia	Pogson	3
47	Aglaja	Luther	6
48	Doris	Goldschmidt	8
49	Pales	Goldschmidt	9
50	Virginia	Ferguson	2
51	Nemausa	Laurent	
52	Europa	Goldschmidt	10
53	Calypso	Luther	7
54	Alexandra	Goldschmidt	11
55	Pandora	Searle	
56	Melete	Goldschmidt	12
57	Mnemosyne	Luther	8
58	Concordia	Luther	9
59	Elpis	Chacornac	6
60	Echo	Ferguson	3
61	Danaë	Goldschmidt	13
62	Förster		
63	Ausonia	DeGasparis	8
64	Angelina	Tempel	1
65	Cybele	Tempel	2
66	Maja	H. P. Tuttle	1
67	Asia	Pogson	4
68	Leto	Luther	10
69	Hesperia	Schiaparelli	
70	Panopæa	Goldschmidt	14
71	Niobe	Luther	11
72	Feronia	C.H.F.Peters	1
73	Clytia	Tuttle	2
74	Galatea	Tempel	3
75	Eurydice	Peters	2
76	Freia	D'Arrest	
77	Frigga	Peters	3
78	Diana	Luther	12
79	Eurynome	Watson	1
80	Sappho	Pogson	5
81	Terpsichore	Tempel	4
82	Alcmene	Luther	13
83	Beatrix	DeGasparis	9
84	Clio	Luther	14
85	Io	Peters	4
86	Semele	Tietjen	
87	Sylvia	Pogson	6
88	Thisbe	Peters	5
89	Julia	Stephan	
90	Antiope	Luther	15
91	Aegina	Borrelly	1
92	Undina	Peters	6
93	Minerva	Watson	2
94	Aurora	Watson	3
95	Arethusa	Luther	16
96	Aegle	Coggia	1
97	Clotho	Tempel	5
98	Ianthe	Peters	7
99	Dike	Borrelly	2
100	Hecate	Watson	4
101	Helena	Watson	5
102	Miriam	Peters	8
103	Hera	Watson	6
104	Clymene	Watson	7
105	Artemis	Watson	8
106	Dione	Watson	9
107	Camilla	Pogson	7
108	Hecuba	Luther	17
109	Felicitas	Peters	9
110	Lydia	Borrelly	3
111	Ate	Peters	10
112	Iphigenia	Peters	11
113	Amalthea	Luther	18
114	Cassandra	Peters	12
115	Thyra	Watson	10
116	Sirona	Peters	13
117	Lomia	Borrelly	4
118	Peitho	Luther	19
119	Althæa	Watson	11
120	Lachesis	Borrelly	5
121	Hermione	Watson	12
122	Gerda	Peters	14
123	Brunhild	Peters	15
124	Alceste	Peters	16
125	Liberatrix	Prosp.Henry	1
126	Velleda	Paul Henry	1
127	Johanna	Prosp.Henry	2
128	Nemesis	Watson	13
129	Antigone	Peters	17
130	Electra	Peters	18

No.	Name.	Discoverer.	Disc. No.	No.	Name.	Discoverer.	Disc. No.
131	Vala	Peters	19	171	Ophelia	Borrelly	8
132	Aethra	Watson	14	172	Baucis	Borrelly	9
133	Cyrene	Watson	15	173	Ino	Borrelly	10
134	Sophrosyne	Luther	20	174	Phaedra	Watson	20
135	Hertha	Peters	20	175	Andromache	Watson	21
136	Austria	Palisa	1	176	Idunna	Peters	27
137	Meliboea	Palisa	2	177	Irma	Paul Henry	6
138	Tolosa	Perrotin	1	178	Belisana	Palisa	10
139	Juewà	Watson	16	179	Clytemnestra	Watson	22
140	Siwa	Palisa	3	180	Garumna	Perrotin	5
141	Lumen	Paul Henry	2	181	Eucharis	Cottenot	
142	Polana	Palisa	4	182	Elsbeth	Palisa	11
143	Adria	Palisa	5	183	Istria	Palisa	12
144	Vibilia	Peters	21	184	Dejopeia	Palisa	13
145	Adeona	Peters	22	185	Eunike	Peters	28
146	Lucina	Borrelly	6	186	Celuta	Prosp. Henry	7
147	Protogeneia	Schulhof		187	Lamberta	Coggia	2
148	Gallia	Prosp. Henry	3	188	Menippe	Peters	29
149	Medusa	Perrotin	2	189	Phthia	Peters	30
150	Nuwa	Watson	17	190	Ismene	Peters	31
151	Abundantia	Palisa	6	191	Kolga	Peters	32
152	Atala	Paul Henry	3	192	Nausicaä	Palisa	14
153	Hilda	Palisa	7	193	Ambrosia	Coggia	3
154	Bertha	Prosp. Henry	4	194	Prokne	Peters	33
155	Scylla	Palisa	8	195	Eurykleia	Palisa	15
156	Xanthippe	Palisa	9	196	Philomela	Peters	34
157	Dejanira	Borrelly	7	197	Arete	Palisa	16
158	Coronis	Knorre		198	Ampella	Borrelly	11
159	Aemilia	Paul Henry	4	199	Byblis	Peters	35
160	Una	Peters	23	200	Dynamene	Peters	36
161	Athor	Watson	18	201	Penelope	Palisa	17
162	Laurentia	Prosp. Henry	5	202	Chryseïs	Peters	37
163	Erigone	Perrotin	3	203	Pompeia	Peters	38
164	Eva	Paul Henry	5	204		Palisa	18
165	Loreley	Peters	24	205		Palisa	19
166	Rhodope	Peters	25	206	Hersilia	Peters	39
167	Urda	Peters	26	207		Palisa	20
168	Sibylla	Watson	19	208		Palisa	21
169	Zelia	Prosp. Henry	6	209	Dido	Peters	40
170	Maria	Perrotin	4				

ALPHABETICAL INDEX OF THE MINOR PLANETS.

No.	Name.	No.	Name.	No.	Name.	No.	Name.	No.	Name.
151	Abundantia	53	Calypso	79	Eurynome	3	Juno	201	Penelope
145	Adeona	107	Camilla	27	Euterpe	191	Kolga	174	Phaedra
143	Adria	114	Cassandra	164	Eva	120	Lachesis	196	Philomela
91	Aegina	186	Celuta	109	Felicitas	39	Laetitia	25	Phocæa
96	Aegle	1	Ceres	72	Feronia	187	Lamberta	189	Phthia
159	Aemilia	202	Chryseïs	37	Fides	162	Laurentia	142	Polana
132	Aethra	34	Circe	8	Flora	38	Leda	33	Polyhymnia
47	Aglaja	84	Clio	19	Fortuna	68	Leto	32	Pomona
124	Alceste	97	Clotho	76	Freia	35	Leucothea	203	Pompeia
82	Alcmene	104	Clymene	77	Frigga	125	Liberatrix	194	Prokne
54	Alexandra	179	Clytemnestra	74	Galatea	117	Lomia	26	Proserpina
119	Althæa	73	Clytia	148	Gallia	165	Loreley	147	Protogeneia
113	Amalthea	58	Concordia	180	Garumna	146	Lucina	16	Psyche
193	Ambrosia	158	Coronis	122	Gerda	141	Lumen	166	Rhodope
198	Ampella	65	Cybele	40	Harmonia	21	Lutetia	80	Sappho
29	Amphitrite	133	Cyrene	6	Hebe	110	Lydia	155	Scylla
175	Andromache	61	Danaë	100	Hecate	66	Maja	86	Semele
64	Angelina	41	Daphne	108	Hecuba	170	Maria	168	Sibylla
129	Antigone	157	Dejanira	101	Helena	20	Massalia	116	Sirona
90	Antiope	184	Dejopeia	103	Hera	149	Medusa	140	Siwa
197	Arete	78	Diana	121	Hermione	137	Meliboea	134	Sophrosyne
95	Arethusa	99	Dike	206	Hersilia	56	Melete	87	Sylvia
43	Ariadne	209	Dido	135	Hertha	18	Melpomene	81	Terpsichore
105	Artemis	106	Dione	69	Hesperia	188	Menippe	23	Thalia
67	Asia	48	Doris	46	Hestia	9	Metis	24	Themis
5	Astræa	200	Dynamene	153	Hilda	93	Minerva	17	Thetis
152	Atala	60	Echo	10	Hygeia	102	Miriam	88	Thisbe
36	Atalante	13	Egeria	98	Ianthe	57	Mnemosyne	115	Thyra
111	Ate	130	Electra	85	Io	192	Nausicaä	138	Tolosa
161	Athor	59	Elpis	176	Idunna	51	Nemausa	160	Una
94	Aurora	182	Elsbeth	173	Ino	128	Nemesis	92	Undina
63	Ausonia	62	Erato	112	Iphigenia	71	Niobe	30	Urania
136	Austria	163	Erigone	14	Irene	150	Nuwa	167	Urda
172	Baucis	181	Eucharis	7	Iris	44	Nysa	131	Vala
83	Beatrix	45	Eugenia	177	Irma	171	Ophelia	126	Velleda
178	Belisana	185	Eunike	42	Isis	49	Pales	4	Vesta
28	Bellona	15	Eunomia	190	Ismene	2	Pallas	144	Vibilia
154	Bertha	31	Euphrosyne	183	Istria	55	Pandora	12	Victoria
123	Brunhild	52	Europa	127	Johanna	70	Panopæa	50	Virginia
199	Byblis	75	Eurydice	139	Juewa	11	Parthenope	156	Xanthippe
22	Calliope	195	Eurykleia	89	Julia	118	Peitho	169	Zelia

2. *Annals of the Astronomical Observatory of Harvard College.* Vol. xi, Part I, Photometric Observations made principally with the equatorial telescope of fifteen inches aperture during the years 1877–79, by EDWARD C. PICKERING, Director, aided by Arthur Searle and Winslow Upton, Assistants in the Observatory. 189 pp. 4to. Cambridge, 1879 (University Press: John Wilson & Son).—The subject of Photometry is that to which the large equatorial of the Harvard Observatory has been devoted since the summer of 1877. The observations necessitated the invention and construction of a new class of instruments, which are described in the first chapter of the volume. Chapter II is devoted to

the journal containing the photometric observations made from August, 1877, to September, 1878, and in part those of October, 1878, to March, 1879; these are numbered from 1 to 5037. Chapter III contains the reduction of the observations of Saturn and Mars, and of Jupiter and Venus at their conjunctions in 1877; and chapter IV contains the discussion of the observations made on the more conspicuous double stars visible in the latitude of Cambridge. This work is one of especial importance because it is the first time that so large an instrument has been entirely devoted to Photometry.

IV. MISCELLANEOUS SCIENTIFIC INTELLIGENCE.

1. *Geological Survey of the Public Domain.*—In volume xvii of this Journal, at page 78 (January number, 1879), the Report of the Committee of the National Academy of Sciences "appointed to consider the Scientific Surveys of the United States" which had been required of the Academy by an act of Congress, is published at length. The Report recommended two distinct departments with reference to such surveys, under separate heads—one for Surveys of Mensuration (to include the Coast and Geodetic surveys, and the topograpical work of the Land Survey office, and the other, for "the determination of all questions relating to the Geological structure and Natural Resources of the Public Domain."

With regard to the latter the report says, "in view, especially of the value of such surveys to the Land Office:"—

"The best interests of the Public Domain require, for the purposes of intelligent administration, a thorough knowledge of its geological structure, natural resources and products. The domain embraces vast mineral wealth in its soils, metals, salines, stones, clays, etc. To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert and swamp lands, a thorough investigation and classification of the acreage of the Public Domain is imperatively demanded. The Committee therefore recommend that Congress establish, under the Department of the Interior, an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geological structure and economic resources of the Public Domain; such a survey to be placed under a Director, who shall be appointed by the President, and who shall report directly to the Secretary of the Interior."

The Report, having been submitted to Congress, was favorably acted upon on March 3d, as regards the second of the two departments recommended in the Report; and, as the passage of the bill is an important event in the history of American scientific surveys, the portion of the Act "making appropriations to Sundry Civil Expenses," which has reference to it, is here cited (pp. 20, 21).

"For the salary of the Director of the Geological Survey, which office is hereby established, under the Interior Department, who shall be appointed by the President by and with the advice and consent of the Senate, six thousand dollars: *Provided*, That this officer shall have the direction of the Geological Survey, and the classification of the public lands and examination of the Geological Structure, mineral resources and products of the National Domain. And that the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations; and the Geological and Geographical Survey of the Territories, and the Geographical and Geological Survey of the Rocky Mountain Region, under the Department of the Interior, and the Geographical Surveys West of the One hundredth Meridian, under the War Department, are hereby discontinued, to take effect on the thirtieth day of June, eighteen hundred and seventy-nine. And all collections of rocks, minerals, soils, fossils, and objects of natural history, archæology, and ethnology, made by the Coast and Interior Survey, the Geological Survey, or by any other parties for the Government of the United States, when no longer needed for investigations in progress, shall be deposited in the National Museum.

"For the expenses of the Geological Survey and the classification of the public lands and examination of the Geological structure; mineral resources and products of the National Domain, to be expended under the direction of the Secretary of the Interior, one hundred thousand dollars;

"For the expense of a commission on the codification of existing laws relating to the survey and disposition of the Public Domain, and for other purposes, twenty thousand dollars;

"*Provided*, That the Commission shall consist of the Commissioner of the General Land Office, the Director of the United States Geological Survey, and three civilians, to be appointed by the President, who shall receive a per diem compensation of ten dollars for each day while actually engaged, and their traveling expenses; and neither the Commissioner of the General Land Office nor the Director of the United States Geological Survey, shall receive other compensation for their services upon said commission than their salaries, respectively, except their traveling expenses, while engaged on said duties; and it shall be the duty of this commission to report to Congress within one year from the time of its organization; first, a codification of the present laws relating to the survey and disposition of the public domain; second, a system and standard of classification of public lands; as arable, irrigable, timber, pasturage, swamp, coal, mineral lands and such other classes as may be deemed proper, having due regard to humidity of climate, supply of water for irrigation, and other physical characteristics; third, a system of land parcelling surveys adapted to the economic uses of the several classes of lands; and, fourth, such recommendations as they may deem wise in relation to the best method of disposing of the public lands of the western portion of the United States to actual settlers.

"The publications of the Geological Survey shall consist of the annual report of operations, geological and economic maps illustrating the resources and classification of the lands, and reports upon general and economic geology and paleontology. The annual report of operations of the Geological Survey shall accompany the annual report of the Secretary of the Interior. All special memoirs and reports of said survey shall be issued in uniform quarto series if deemed necessary by the Director, but otherwise in ordinary octavos. Three thousand copies of each shall be published for scientific exchanges and for sale at the price of publication; and all literary and cartographic materials, received in exchange shall be the property of the United States and form a part of the library of organization: and the money resulting from the sale of such publications shall be covered into the Treasury of the United States, under the direction of the Secretary of the Interior; one hundred thousand dollars;

"For the preparation of reports, maps, and such other illustrations as may be necessary for completing the office work of the Geological and Geographical Survey of the Territories, twenty thousand dollars; to be immediately available.

"For the completion of the reports of the Geographical and Geological Survey of the Rocky Mountain Region with the necessary maps and illustrations, twenty thousand dollars; to be immediately available.

"For the preparation of reports, maps and such other illustrations as may be necessary for completing the office work of the Geographical Surveys West of the One hundredth Meridian, under the direction of the Secretary of War, twenty thousand dollars; to be immediately available."

The office of Director of the Geological Survey, "to have the direction of the Geological Survey, and the classification of the public lands, and examination of the geological structure, mineral resources and products of the *National Domain*," was thus established; and soon after, the position of Director of the Survey was given to Mr. Clarence King, who by long work in the field had already become well acquainted geologically with much of the National Domain over which his surveys were to extend.

The failure of Congress to act favorably with reference to the establishment of "Mensuration Surveys," recommended in the Report of the Committee of the Academy, is thought to be a deferring of the subject for the time, and not a rejection of the scheme.

Another move with regard to the department of the Geological Survey has been made since Mr. King received his appointment, and one which has not yet been laid before a Committee of the National Academy, and has not even been presented for public discussion, although it bears on the political and industrial interests of the country, as well as on the status of Science under the General Government.

The session of Congress, in which the Department of the Geological Survey of the Public Domain was established, was followed by an extra session which closed on the 1st of July. The Congressional Record of the 29th of June reports that a resolution was introduced into the House of Representatives, adding after the words "National Domain" in the first paragraph of the former bill, the three words "and the States." (See the eighth line in this paragraph, on page 493). It says, further, that the resolution was discussed at length, and that, finally, an amendment passed the House, substituting, for the three words, the following—to be introduced at the same place: "and he may extend his examinations into the States." The resolution failed of being brought before the Senate for want of time.

With the words "and the States" inserted, the area geologically and economically under the Director's supervision becomes suddenly enlarged to the dimensions of the whole country from the Atlantic to the Pacific. The geological surveys of all the several States come under the control, and their prosecution is made the duty, of the General Government; and the work of exploring their mining and other resources, is also assumed by this new United States department. And this is the view which the Director takes of the amendment adopted by the House; for he personally informed the writer after the adjournment of Congress, that it was his purpose, under the act, to send a party into New England next spring.

Having been a member of the National Academy, the writer has felt it a duty here to state, that this proposed expansion of the field of work under the "Director of the Geological Survey" is wholly foreign to the views expressed in the Report of the Committee, and to the opinions brought out in their discussions. Moreover, it is entirely at variance with the objects set before the Committee by the Act of Congress requiring its appointment: this act asking that the members "take under consideration the methods and expenses of conducting all surveys of a scientific character under the War or Interior Department and the surveys of the Land Office, and to report to Congress, as soon thereafter as may be practicable, a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best results at the least possible cost." The plan set forth by the Committee, besides having direct reference to the Territories, had in view that economy of expenditure, suggested in the act of Congress; while the new scheme, with the proposed enlargement of its scope, would involve—as State geological surveys have shown—millions of outlay for the strictly geological part, and indefinite millions besides for the economical branch—the study of "the mineral resources and products of the National Domain" "*and the States.*"

The writer is not informed as to the character of the discussion over the proposed amendment in the House of Representatives. But it seems to be plain, from the change of wording, that the meaning intended to be conveyed by it was that the Director "may extend his examinations into States" *which adjoin the*

Territories. There is an evident absurdity in an expression which adds the States—nearly the whole country—to the Territories. Had the general survey of the United States been intended by the House, the idea would have been brought out by the simple substitution of the words United States for "National Domain."

A change so great in the administration of the affairs of the Government should have a full discussion before it is accepted. It will appear to many that the Constitution has left to the States the making of their own geological surveys and the study of their own economical resources—as past history seems to attest—and that such an infringement on State rights and assumption of State responsibilities would be politically wrong; and also, that investigations into the mineral resources of the States, whether of a mine or of a granite quarry, would be followed by other evils through encroachments on private rights, and the temptations to favor private enterprises. The General Government, unlike many in foreign lands, has no ownership in the mines of California or of any other of the States, and hence has no need to establish a Mining Bureau for the country at large.

The States, for the most part, have carried forward geological surveys. The great need, previous to undertaking new surveys, in order that they may be correct and complete, is, for each, an accurate topographical survey. Before New England, or any part of this or of the other sections of the Union, has again its corps of geological surveyors, it should have in the field, for a number of years, corps of geodetic and topographical surveyors,—preparing maps in which roads, rivers, hills, mountains, State-lines, county-lines, town-lines, and all positions, are correctly given.

Within four years a scheme for the scientific survey of Connecticut has been brought before the legislature of the State by a committee which included the writer among its members. And this committee urged, in its petition, that, *first*, a topographical survey should be made in order that a satisfactory geological survey might be a possibility. It was manifest that without such a preparation the work would be half a waste of expenditure, and have to be done over again.

Topographical surveys are needed in every State as well as Territory; and for this purpose there is manifestly required the establishment of a Department of "Mensuration Surveys," under the General Government, whose geodetic work over the breadth of the country shall, in accordance with some well devised plan, be supplemented by topographical work at the expense, and under the united supervision, of the State and General Government. This done, the States could easily carry forward their own scientific and economical surveys. JAMES D. DANA.

2. *Chemical Denudation in relation to Geological Time;* by T. MELLARD READE. 62 pp. 8vo. London, 1879. (David Bogue.)—Mr. T. Mellard Reade gives, in his memoir, the results of his comparisons of the amount of denudation in various regions over

the globe, and of various considerations derived from the constitution of the earth's crust, the composition of river and sea waters and deep-sea and shallow-sea formations. He closes his volume with the conclusion that the minimum amount of time required to make the world's limestone strata is "in round numbers say 600,000,000 years;" and that this time is divided about equally between (1) the Silurian and Pre-silurian; (2) the rest of the Paleozoic ages and Triassic; and (3) the remainder of geological time. After all, this question of time geological science knows little about, beyond the general fact of its almost indefinite length.

3. *Report No. 2, of the Princeton Scientific Expedition of 1877: Topographic, Hypsometric and Meteorologic Report*, by W. LIBBEY, Jr., and W. W. MCDONALD. 56 pp. 8vo, with an Appendix of 28 pp. New York, 1879.—This Report contains geological as well as topographic information respecting the region visited by the Princeton Expedition, and has many beautiful "artotype" plates representing scenes in the mountain regions remarkable as illustrations of erosion and other geological phenomena. The height determined by the Expedition for Pike's Peak was 14,147·28 feet (made 14,146·56 by Hayden's expedition); for Mount Lincoln 14,297·80 (14,297·00 Hayden); for Mount Silverheels 13,861 (13,897 Hayden); for Mount Princeton 14,208·90 (14,196 Hayden, 14,041 Wheeler's Expedition); for Mount Evans 14,353·30 (14,340 Hayden); Mount Gray 14,363·30 (14,341 Hayden); Mount Bross, 14,255 feet; Mount Alma, 10,364·50 (10,254 Wheeler's Expedition).

4. *Lectures and Essays by the late William K. Clifford, F.R.S.*, edited by LESLIE STEPHEN and FREDERICK POLLOCK; with an introduction by F. Pollock. In two volumes, 8vo. London, 1879. (Macmillan & Co.).—The sketch, which opens this work, was written by a personal friend of the late Professor Clifford, and hence one well able to speak of him. While not attempting to be a complete biography, it brings out clearly the prominent points in the mental character and the attainments of the gifted mathematician, whose work was so suddenly interrupted. The lectures and essays contained in these two volumes are for the most part of a philosophical rather than a strictly scientific character, and hence it lies outside of the province of this Journal to give an extended notice of them. They are characterized by the clear and vigorous thought which was shown in all the work of their author. It is well both for his sake and for that of the public that they have been preserved and presented in this form.

5. *Seeing and Thinking*; by the late WILLIAM K. CLIFFORD, F.R.S. 156 pp. 8vo. London. (Nature Series: Macmillan & Co.). —Four lectures delivered by Professor Clifford at Shoreditch; they bear the titles: the Eye and the Brain; the Eye and seeing; the Brain and thinking; of Boundaries in general. They contain many important scientific facts presented in so simple a manner and with such fullness of illustration as to be intelligible even to those who have had no scientific training.

6. *The Mound Builders; Archæology of Butler County, Ohio;* by J. P. MacLean. 234 pp. 8vo, illustrated with over 100 figures. Cincinnati. (Robert Clarke & Co.)—Two-thirds of this volume are devoted to the general subject of the mound builders, and give a well digested account of the observations and results hitherto obtained. The remainder is devoted to an account of the ancient earth-works and Indian relics of Butler County, in southwestern Ohio, a region containing more of such earth-works than any other county in the State; their number is seventeen, and one of them covers an area of 95 acres. Many figures are given representing stone arrow-heads, implements and ornaments, and also plans of the earth-works, besides an Archæological map of the county.

7. *Maps of the U. S. Geological and Geographical Survey of the Territories,* F. V. Hayden, Geologist-in-Charge.—Five maps of this Survey have recently been issued, 20 to 26 by 36 inches in size, illustrating the topography and geography of portions of Utah, Idaho and Wyoming territories, and they are remarkable for beauty of execution, while of great interest for the region they illustrate. The Primary triangulation in the survey was carried forward by A. D. Wilson, and the topography by H. Gannett, G. B. Chittenden, G. R. Bechler and F. A. Clark. These maps include a drainage map, a map of the Yellowstone National Park on a scale of two miles to an inch, and maps of other portions of the Territories named, giving the altitudes of numerous measured peaks, and by means of contour lines, the character of the various mountain ranges and plateaus, including the Wind River Mountains, the Bear River Range, the Teton Range, the Snake River Range, and others. The engraving is by J. Bien.

Notices of the following new works are deferred to another number:

Report on the Geology of the Henry Mountains, by G. K. Gilbert. 160 pp. 4to. U. S. Geographical and Geological Survey of the Rocky Mountain Region, J. W. Powell, in charge. Department of the Interior.

Pennsylvania Second Geological Survey. Harrisburg, 1879. (1.) Second Report of Progress in the Laboratory of the Survey at Harrisburgh, by Andrew S. McCreath. 438 pp. 8vo.—(2.) Report, Part first, on the Northern townships of Butler County; Part second, on a Special Survey along the Beaver and Shenango Rivers, by H. Martyn Chance. 248 pp. 8vo, with 6 maps, 1 profile section and 154 vertical sections.

A Manual of Palæontology for the use of students, with a general introduction on the principles of Palæontology, by Henry Allyn Nicholson, Prof. Nat. Hist. Univ. St. Andrews. Second edition, revised and greatly enlarged. 2 volumes, with numerous illustrations. 1879, Edinburgh and London. (Wm. Blackman & Sons.)

Geological Survey of Alabama, Report of Progress for 1877, 1878, by Eugene A. Smith, Ph.D., State Geologist. 140 pp. 8vo. Montgomery, Alabama, 1879.

Solar Light and Heat: the Source and the Supply. Gravitation with explanation of Planetary and Molecular Forces, by Zachariah Allen, LL.D. 241 pp. 8vo. New York, 1879. (D. Appleton & Co.)

OBITUARY.

James Clerk Maxwell, F.R.S.—By the early death of Professor Maxwell in his forty-ninth year the University of Cambridge has sustained a loss which will be felt as personal by all students of physical science. He entered perhaps more thoroughly than any of his contemporaries into the splendid inheritance of scientific speculation left behind by Faraday, and though he has made invaluable additions to that inheritance, the world must ever regret that to one so gifted the time should have been denied for attaining the great results which seem, as we read his papers, to have been so nearly within his grasp.

James Clerk Maxwell, scholar of Trinity College, Cambridge, took his degree as Second Wrangler in the Mathematical Tripos of 1854. He became a fellow of his college in 1855, and accepted the chair of Physics in the Marischal College, Aberdeen, in 1856, which he held until the amalgamation of the College with King's College. In 1860 he was elected Professor of Physics in King's College, London, where he remained till 1865. But he was not in his element as a lecturer, and it was not until his appointment in 1871 to the professorship of Experimental Physics in Cambridge, with the direction of the laboratory which the munificence of the Duke of Devonshire shortly afterwards presented to the University, that he found himself in a position thoroughly suited to his tastes and abilities.

His chief contributions to the progress of science are to be found in the numerous series of his papers. Among the earlier of these are several discussions of great interest regarding the action of colors on the retina, with especial reference to the phenomena of color blindness. His classical paper on Saturn's rings was published in the Astronomical Society's Notices for 1859. In this he proved that the theory of the solidity of the rings is untenable, and that they probably consist of an almost continuous congeries of meteorites. He also had a share in the determination of one of the most important scientific measurements that have been made in recent times, the formation, namely, of the standard known as the British Association Unit of Electrical Resistance, an account of which appears in the British Association Report for 1864.

But the subject which had most attraction for him was the inquiry into the ultimate constitution of matter and the mechanism which produces the phenomena of force, whether electrical or gravitational. Masterly expositions by him of the dynamical theory of gases are to be found in the British Association Report for 1859, the Philosophical Magazine for 1860, the Philosophical Transactions for 1867, the article on "Atoms" of the new Encyclopædia Britannica, and in his only too concise and pregnant Theory of Heat. It is, however, with his attempts at a mechanical theory of electricity, magnetism and light that his name will be, in all probability, most closely associated in future. He thoroughly endorsed Faraday's rejection of the theory of electrical action at a distance, and sought, with him, to explain all electrical and magnetic phenomena as the results of local strains and motions in a medium whose contiguous parts only act on one another by pressure and tension. Though many of Maxwell's results are contained in his great Treatise on Electricity and Magnetism, the student will not willingly pass over his papers on Molecular Vortices, in vols. xxi and xxiii of the Philosophical Magazine, or his Dynamical Theory of the Electromagnetic Field, in the Proceedings of the Royal Society in 1864. Such luminous imagination together with originality of conception is shown in these speculations that the reader feels Professor Maxwell's genius no less in his own inability to follow them out to their conclusion than in his certainty that the guide we have lost could have knit them together into a magnificent induction if only the full term of life had been allotted to him.

This is the regret that the world of science at large feels. Those only whose privilege it was to study under Professor Maxwell's direction can rightly estimate that genial kindness and sympathy which, no less than his genuine enthusiasm, so inspirited them that they know not whether they labored more from love for their science or from regard for their master.—*Athenæum, Nov.* 15.

APPENDIX.

ART. LIX.—*Notice of New Jurassic Reptiles;* by Professor O. C. MARSH. With Plate III.

NUMEROUS remains of Reptiles from the Jurassic deposits of the Rocky Mountains have recently been received at the Yale Museum, and some of the more interesting Dinosaurs are here briefly described. These pertain to several distinct groups, and throw considerable light on the forms already described from the same horizon.*

Camptonotus dispar, gen. et sp. nov.

The present genus is most nearly allied to *Laosaurus*, but differs in several points. The cervical vertebræ are all opisthocœlous, while those known in *Laosaurus* are nearly plane. The pubis, moreover, is broad and thin in front of the acetabulum, and directed well forward. It has a deep, well marked articular face for the support of the femur. The ischium is expanded at its distal end, and has an extensive surface for union with its fellow. The femur is longer than the tibia.

This genus agrees with *Laosaurus* in one important character, namely, the sacral vertebræ are not coössified. That this is not merely a character of immaturity is shown by some of the other vertebræ in the type specimen, which have their neural arches so completely united to the centra that the suture is nearly or quite obliterated. To this character of the sacral vertebræ, the name of the present genus refers. With *Laosaurus*, this genus forms a distinct family, which may be called *Laosauridæ.*

The teeth in *Camptonotus* resemble those of *Laosaurus*, and are in a single row in close-set sockets. The rami of the lower jaws were united in front only by cartilage. There are nine cervical vertebræ, all of which bear short ribs, as in the Crocodiles. The dorsal vertebræ have their articular faces nearly plane. The sacral vertebræ in all the known specimens are separate, and their transverse processes are each supported by two centra. (Plate III, figure 3). The chevrons have their articular faces joined together.

The fore limb is much reduced in size. There are five digits in the manus, supported by nine carpal bones, three of which are united in one on the radial side. The number of phalanges, beginning with the first digit, was 2, 3, 3, 3, 2. The form and proportions of the various elements of the fore limb are shown in Plate III, figure 1.

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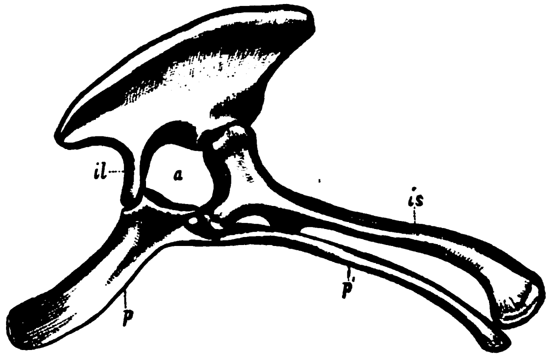
* This Journal, vol. xvi, p. 411; and vol. xvii, pp. 85 and 181.

The pelvic arch is quite unlike any hitherto described. In its general form the ilium resembles that of *Morosaurus*, but the proportions are reversed. The massive portion in the present genus is not in front, but behind, as the ischium is larger than the pubis. The relative position and form of the elements of the pelvic arch are shown in the figure below.



Pelvic arch of *Camptonotus dispar*, Marsh; side view, one twelfth natural size. *a.* acetabulum; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* postpubis.

The femur has a long pendant third trochanter, and a prominent ridge to play between the tibia and fibula. The tibia is stout, and somewhat shorter than the femur. The fibula is slender, and shorter than the tibia. The astragalus and calcaneum are distinct. The second row of tarsals contains but two bones. The first digit in the pes was rudimentary, and did not reach the ground. The second, third and fourth were well developed. The fifth was entirely wanting. The number of phalanges, beginning with the first digit, was 2, 3, 4, 5. The structure of the hind limb and foot is well shown in Plate III, figure 2, which is taken from the same skeleton as figure 1.

Some of the principal measurements of the present species are as follows:

United length of the nine cervical vertebræ	565$^{\cdot mm}$
Length of axis	54·
Transverse diameter of posterior articular face	41·
Length of ninth cervical vertebra	64.
Transverse diameter of posterior articular face	63·
Length of humerus	337·
Length of radius	245·
Length of ulna	260·
Length of femur	565·
Length of tibia	555·

The known remains of this species indicate an animal about eight or ten feet in height, and herbivorous in habit. All the specimens discovered are from the Atlantosaurus beds of the Upper Jurassic.

Camptonotus amplus, sp. nov.

A second species of this genus, about three times as large as the one just described, is represented by various remains, among which is a left hind foot nearly entire. There were three functional digits in this foot, the first being rudimentary, and the fifth entirely wanting. The metatarsal of the first digit is a splint, much curved, and with the apex above. The terminal phalanx of this digit is much compressed, not round as in the smaller species. The second metatarsal is of much greater length. The terminal phalanx of this digit is longer in proportion than that of the preceding species. The third and fourth digits were large and powerful. The main dimensions of this foot are as follows:

Length of second metatarsal	295·$^{\rm mm}$
Greatest diameter of proximal end	113·
Length of third metatarsal	345·
Greatest diameter of proximal end	150·
Transverse diameter of distal end	102·
Length of fourth metatarsal	305·
Length of first phalanx of third digit	140·
Length of first phalanx of second digit	120·

The remains of the present species are from a lower horizon in the Jurassic than those described above, but within the limits of the Atlantosaurus beds.

Brontosaurus excelsus, gen. et sp. nov.

One of the largest reptiles yet discovered has been recently brought to light, and a portion of the remains are now in the Yale collection. This monster apparently belongs in the *Sauropoda*, but differs from any of the known genera in the sacrum, which is composed of five thoroughly coössified vertebræ. In some other respects it resembles *Morosaurus*. The ilium is of that type, and could hardly be distinguished from that of *M. robustus*, excepting by its larger size. One striking peculiarity of the sacrum in the present genus is its comparative lightness, owing to the extensive cavities in the vertebræ, the walls of which are very thin.

The lumbar vertebræ have their centra constricted, and also contain large cavities. The caudals are nearly or quite solid. The chevrons have their articular heads separate. The sacrum of this animal is, approximately, 50 inches (1·27$^{\rm m}$) in length. The last sacral vertebra is 292$^{\rm mm}$ in length, and 330$^{\rm mm}$ in transverse diameter across the articular face.

A detailed description of these remains will be given in a subsequent communication. They are from the Atlantosaurus beds of Wyoming. The animal was probably seventy or eighty feet in length.

Stegosaurus ungulatus, sp. nov.

Additional specimens of *Stegosaurus* have been recently secured from several localities, and much new information in regard to the group has thus been obtained. These reptiles belong to the Dinosauria, but differ widely from any of the known suborders. The most striking character, to which the name refers, is the huge dermal plates which protected the animal. A number of these, from two to three feet in diameter, and others of smaller size, were found with the remains of the present species.

The skull is very small, and more lacertilian than in the typical Dinosaurs. The brain cavity is remarkably small.

The vertebræ known are all solid, and have nearly plane or slightly concave articular extremities. The fore limbs are shorter than those behind. In the present species, the humerus is very short, and the ulna has a very large olecranon process. The terminal phalanges preserved are short, broad, and obtuse, as in some ungulate mammals. The femur is long, entirely without a third trochanter, and the ridge between the tibia and fibula is only faintly indicated. The tibia is of moderate length, and the astragalus is firmly coössified with it. The fibula is slender, and united firmly with the calcaneum and lower end of the tibia. The present species may prove to be generically distinct from the type species, *Stegosaurus armatus*,* described by the writer from a different locality.

In one specimen of the present species, some of the more important dimensions are as follows:

Transverse diameter of occipital condyle	44·mm
Vertical diameter	25·
Transverse diameter of foramen magnum	31·
Greatest transverse diameter of brain cavity	33·
Length of third cervical vertebra	85·
Length of humerus	590·
Length of tibia with astragalus	750·
Length of terminal phalanx	85·
Greatest width	70·

Cœlurus fragilis, gen. et sp. nov.

A very small reptile, apparently a Dinosaur, left its remains in the same locality with *Camptonotus dispar*. The most characteristic specimens obtained are vertebræ, which in the dorsal and lumbar region have their centra so much excavated that the walls are reduced to a thin shell. There are apparently no partitions across their cavity, and the inner surface of the walls is quite smooth. The anterior caudal vertebræ, at least, have essentially the same character. The trunk vertebræ preserved are elongate, biconcave, with high neural arches, united to the centra by suture. The sides of the vertebræ are somewhat excavated, and the openings into the cavity are all small. The cup at each end of the centra is unusually smooth, and regular. The zygapophyses are near together, and stand nearly vertical.

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* This Journal, vol. xiv, p. 513, Dec., 1877.

The following measurements will indicate the size of this animal:

Length of centrum of lumbar vertebra	35·mm
Transverse diameter of anterior face of centrum	19·
Vertical diameter	21·
Least transverse diameter of centrum	10·
Least thickness of walls of centrum	1·
Length of anterior caudal	33·
Transverse diameter of anterior face	17·
Thickness of walls of centrum, near middle	1·
Least transverse diameter of centrum	10·

The known remains of this species indicate an animal about as large as a wolf, and probably carnivorous.

Yale College, New Haven, November 18, 1879.

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PLATE I.

STORM OF OCT. 21 1873.

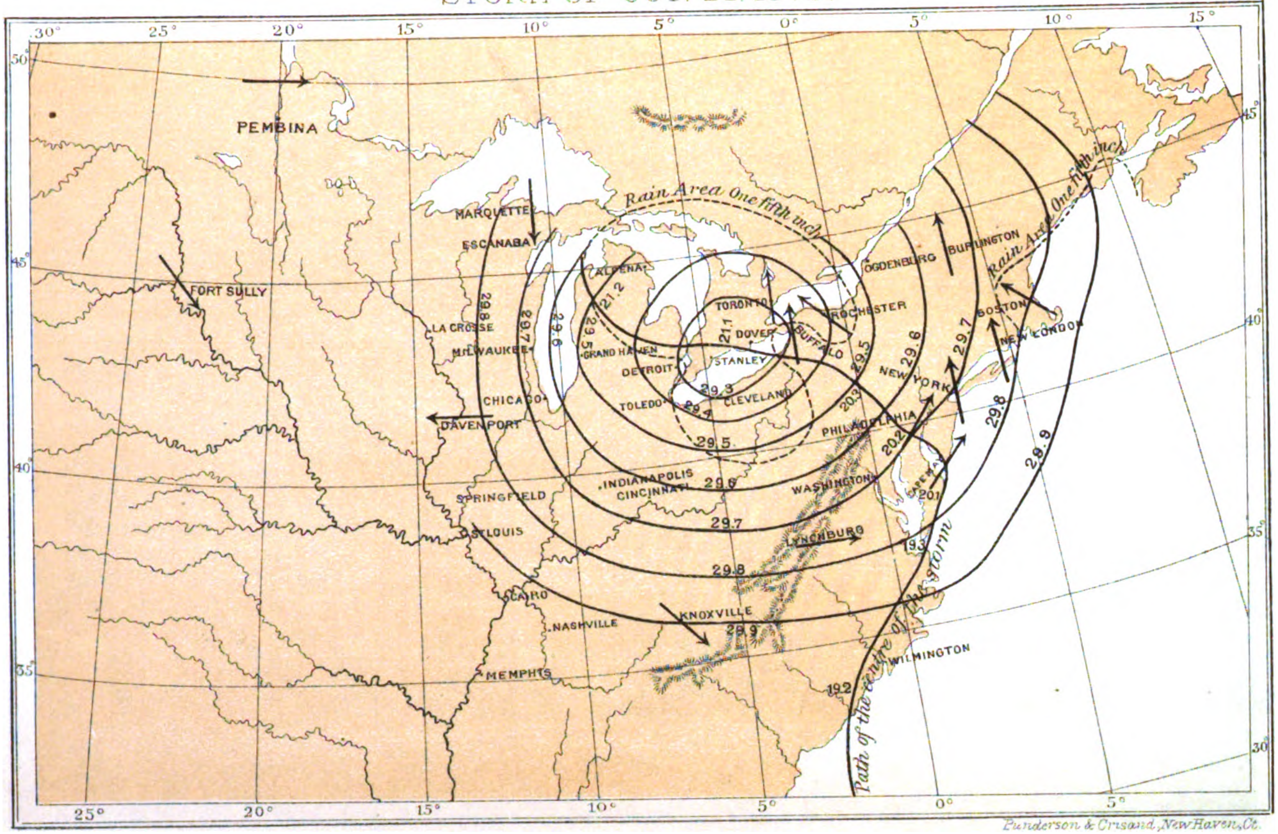

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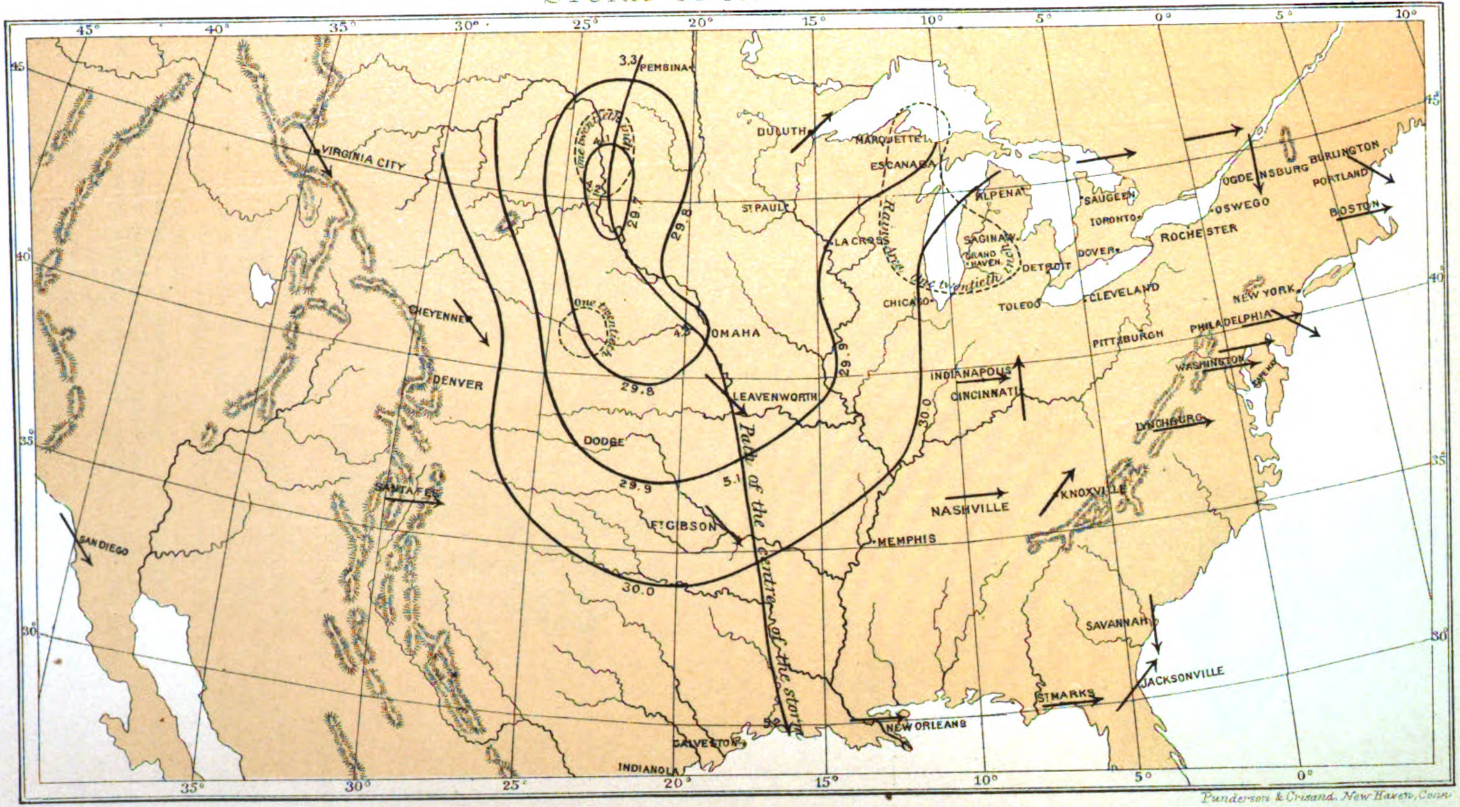
PLATE II.

STORM OF JAN. 4 1877.



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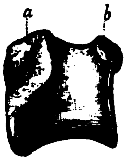

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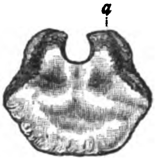

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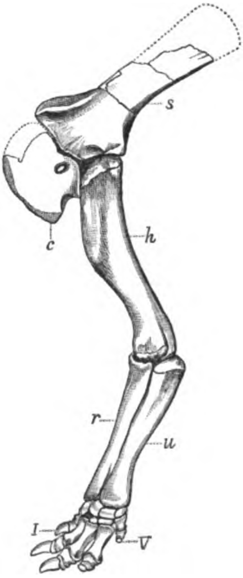

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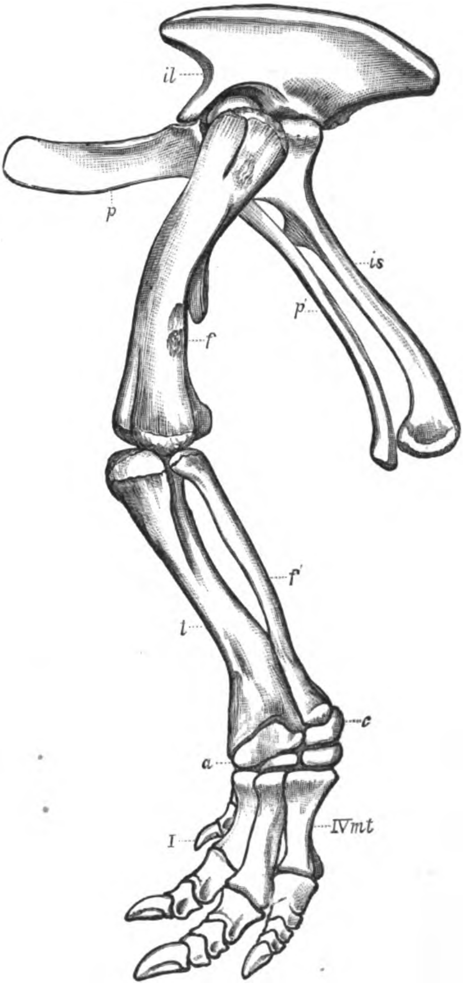

Figure 1.—Bones of left fore leg of *Camptonotus dispar*, Marsh; *s.* scapula; *c.* coracoid; *h.* humerus; *r.* radius; *u.* ulna; I. first digit; V. fifth digit.

Figure 2.—Bones of left hind leg of *Camptonotus dispar*; *il.* ilium; *is.* ischium; *p.* pubis; *p'.* post-pubis; *f.* femur; *t.* tibia; *f.'* fibula; *a.* astragalus; *c.* calcaneum; I. first metatarsal; IV*mt.* fourth metatarsal. Both figures one twelfth natural size.

Figure 3.—Sacral vertebra of same individual, seen from the left. *a.* anterior face for transverse process; *b.* posterior face.

Figure 4.—The same vertebra, front view. Both one sixth natural size.